GUIDELINES FOR CONTROL AND PREVENTION OF MULTI-DRUG RESISTANT ORGANISMS (MDROS) IN HEALTHCARE FACILITIES

Contents

Chapter 1 National Infection Prevention and Control of MDROs 9
A. Emerging versus Endemic MDROs 9
B. Role of National Agencies 11
C. Role of Antimicrobial Management in Healthcare Facilities 13
D. Communication Within and Between Healthcare Facilities 13
E. Escalation and Containment of New MDROs or MDRO Clusters and Outbreaks 16
Chapter 2 Infection Prevention and Control Measures for MDROs in Healthcare Settings 19
A. Infection Prevention and Control Programme and Risk Assessment 19
B. Precautionary Measures 22
C. Specific Guidance on Emerging and Endemic MDROs 24
D. Intensified Interventions to Prevent MDRO Transmission 25
E. Infection Prevention and Control Measures for MDRO in Settings Outside of Acute Care Institutions or Facilities 26
I. MDRO-colonised Patients in Residential ILTC Facilities and Dialysis Centres 27
II. MDRO-colonised Patients in Non-Residential ILTC Facilities (Excluding Dialysis Centres) and Other Ambulatory Care Settings 29
III. MDRO-colonised Persons at Home or in Social Homes 30
Chapter 3 Methicillin-resistant *Staphylococcus aureus* (MRSA) 33
A. Active Surveillance Cultures for MRSA in Acute Care Institutions or Facilities 33
B. Active Surveillance for MRSA in Residential ILTCs 33
C. Bed Management of MRSA patients in Acute Care Institutions or Facilities 34
D. Management of MRSA patients in ILTCs 34
E. MRSA Clinical Information Records and Criteria for Tagging and Untagging MRSA Cases 34
F. Specific Data Collection and Reporting Requirements for MRSA 36
Chapter 4 Vancomycin Resistant *enterococcus* (VRE) 37
A. Infection Control Measures 37
B. Criteria for Isolation for Patients with VRE in Acute Care Institutions or Facilities 37
C. Removal from Isolation or Cohorting of Patients in Acute Care Institutions or Facilities 38
D. VRE Clinical Information Records and Criteria for Tagging and Untagging VRE Cases 38
E. Management of VRE patients in ILTCs 39
F. Specific Data Collection and Reporting Requirements for VRE 39
Chapter 5 Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE) 41

A. Background 41
B. Risk Factors and Mode of Transmission 42
C. Clinical Significance 43
D. Infection Control and Prevention Measures for CP-CRE 43
E. Laboratory Identification of CP-CRE in Screening Samples 44
F. CP-CRE Clinical Records Information and Criteria for Tagging and Untagging CP-CRE Cases 45
G. Infection Control Recommendations for the Acute Care Institution or Facility Setting 46
H. Infection Control Recommendations for Settings Outside Acute Care Institutions or Facilities 47
I. Nursing Homes 47
J. Specific Data Collection and Reporting Requirements for CP-CRE 49
Appendix 1: Definitions and Abbreviations Used in the Document 54
Appendix 2: Summary of Precautionary Measures for MDRO patients 57
Appendix 3 Laboratory Diagnosis of MRSA, VISA and VRSA 63
Appendix 4 Laboratory Diagnosis of VRE 64
Appendix 5 Laboratory Diagnosis of CP-CRE 65
Appendix 6 *Clostridium difficile* 68
Appendix 7: Data Collection and Reporting Requirements for MDROs 72
Appendix 8: Credits for MDRO Guidelines Development 77

Executive Summary

1. Healthcare institutions worldwide are increasingly faced with the emergence and transmission of multidrug-resistant organisms (MDROs). Patients can be harmed by MDRO infections. Left unchecked, the spread of MDROs will also increase the burden on healthcare infrastructure e.g. isolation rooms, as well as increase healthcare costs.

2. The prevention and control of MDROs is a national priority. Leadership and coordinated response by the Ministry of Health (MOH) and all relevant national agencies are critical. All healthcare institutions must participate in national MDRO control efforts. The national objective in controlling emerging or new MDROs of low incidence should be to contain the spread of these organisms in all Singapore healthcare facilities and prevent them from becoming endemic. For MDROs already endemic, the national objective should be to control and reduce their incidence in all Singapore healthcare facilities.

3. Nationally, there must be good communication and coordination on MDRO issues. Positive clinical or screening cultures for MDROs (MDRO clinical records information) should be communicated ***appropriately*** between healthcare facilities (taking into consideration principles of patient confidentiality) to allow appropriate infection prevention and control (IPC) measures to be taken in the receiving facility. The aim of tagging and untagging MDRO patients ***within*** a healthcare facility is so that the healthcare facility can act on this risk information and take the necessary IPC precautions. Tagging and untagging information is NOT for the purposes of informing another healthcare facility as different healthcare facilities have different IPC risk. Instead the appropriate MDRO clinical records information should be communicated between healthcare facilities, taking into consideration principles of patient confidentiality.

4. Responses to MDRO clusters and outbreaks must be aggressive to contain and prevent spread to other patients and healthcare facilities. Escalation of new MDRO cases, clusters or outbreaks to MOH in a timely manner is critical should national level assistance or coordination be required to support and/or direct institutional infection control efforts or outbreak investigation.

5. Patient safety and the practice of appropriate infection prevention and control is the responsibility of all healthcare institutions. All healthcare institutions must have a comprehensive IPC programme that is developed based on an understanding of the risks, capabilities and capacity, and challenges within each healthcare facility. An MDRO Risk Assessment, best done annually, will give guidance to the institution's MDRO programme.

6. All healthcare institutions should build up IPC capabilities and capacity to ensure appropriate Infection Control precautions when patients present with MDROs. All healthcare institutions should have the ability to mobilize appropriate resources to support their MDRO Surveillance, Risk Assessment and IPC programme. No patient should be declined admission to any healthcare facility because of carriage of MDROs.

7. Measuring the compliance with IPC precautionary measures on a routine basis, as well as enabling the benchmarking of IPC data will provide the healthcare institution with information on its success in these interventions. Implementation of an MDRO bundle will help the institution or facility monitor and ensure compliance.

8. Methicillin-resistant *Staphylococcus aureus* (MRSA) is endemic in many healthcare facilities and efforts to minimize transmission should continue. The incidence of vancomycin-resistant *enterococcus* (VRE) is increasing and similar efforts should be made to minimize transmission.

9. Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE) has emerged as a worldwide threat since first being recognized in mid-2000s. They leave almost no antimicrobial options for those infected. Enhanced Infection Control measures, including active surveillance, are needed. Healthcare institutions need to be vigilant and intervene decisively and appropriately to maintain a low prevalence in Singapore.

Introduction

Healthcare institutions worldwide are increasingly faced with the emergence and transmission of multidrug-resistant organisms (MDROs). Multidrug-resistant organisms (MDROs), including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococcus* (VRE) and carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE) have important patient safety and healthcare system implications.

Patients can become unnecessarily harmed as a result of MDRO infections. Left unchecked, the spread of MDROs will also increase the burden on healthcare infrastructure e.g. isolation rooms, as well as increase healthcare costs. Vigilant infection control, amongst other strategies to control antimicrobial resistance through management of antimicrobial utilization is needed.

As such, the prevention and control of MDROs is both a national priority, as well as a priority of healthcare institutions or facilities. Chapter 1 of this document provides recommendations and considerations for national infection prevention and control (IPC) of MDROs. The chapter covers topics such as emerging and endemic MDROs, role of national agencies such as the Ministry of Health (MOH) and the National Public Health Laboratory (NPHL), coordination of national MDRO control efforts, as well as guidance on expedited flow of information between healthcare institutions and MOH, including escalation and containment of new MDROs, MDRO clusters and outbreaks. The role of appropriate antimicrobial management is also briefly discussed in Chapter 1.

Chapter 2 provides detailed guidance on the infection prevention and control measures for MDROs in healthcare settings. The Chapter includes guidance for different healthcare setting such as acute care institutions or facilities, residential intermediate and long-term care (ILTC) facilities, as well as non-residential ILTC facilities and other ambulatory settings.

Finally, specific measures for the different MDROs, as well as detailed data collection and reporting requirements for MDROs are also detailed in the respective MDRO chapters (see Chapter 3 Methicillin-resistant *Staphylococcus aureus* (MRSA), Chapter 4 Vancomycin Resistant *enterococcus* (VRE), Chapter 5 Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE).

In addition, guidance on IPC strategies and practices within healthcare settings are also detailed. Although *Clostridium difficile* is not a MDRO, it is included as an Appendix in this MDRO guideline to give some guidance to institutions on the management of patients or residents with this organism.

Chapter 1 National Infection Prevention and Control of MDROs

The prevention and control of MDROs is a national priority – one that requires all healthcare facilities to assume and exercise responsibility in MDRO prevention and control. Achieving control within healthcare institutions alone is insufficient since MDROs do not respect institutional boundaries. Healthcare institutions must participate in national MDRO control efforts.

Leadership and facilitation by MOH and all relevant national agencies are critical. Financial and human resources must also be made available to enable IPC efforts. These include expert consultation, laboratory support, adherence monitoring, and data analysis.

There must be good communication and coordination on MDRO issues between healthcare institutions, and between healthcare institutions and national agencies such as MOH and NPHL. Responses to MDRO clusters and outbreaks must be aggressive to contain and prevent spread to other healthcare facilities. The aim should be to reduce, and where possible, eliminate all patient harm that is caused by MDROs. Doing so will also bring about improvements to the operational efficiency of our healthcare system, as well as reduce costs.

A. Emerging versus Endemic MDROs

Emerging or new MDROs of low incidence are occasionally identified because of better technology or as a result of widespread use of broad spectrum antimicrobials over time. Refer to

Appendix 1: Definitions and Abbreviations Used in the Document for a list of pathogens currently classified as emerging in Singapore healthcare institutions, for example CP-CRE, vancomycin-resistant *Staphylococcus aureus* (VRSA). In the management of these MDROs, the national objective should be to contain the spread of these organisms in all Singapore healthcare facilities and prevent them from becoming endemic.

Endemic MDROs refers to MDROs with relatively high but stable incidence. Refer to

Appendix 1: Definitions and Abbreviations Used in the Document for a list of pathogens currently classified as endemic in Singapore healthcare institutions. This list is not exhaustive, and each institution should develop its own MDRO reduction program to include target pathogens of interest, for example multi-resistant *Pseudomonas*, multi-resistant *Acinetobacter* species. For MDROs that are already endemic, the national objective should be to control and gradually reduce their incidence in all Singapore healthcare facilities.

B. Role of National Agencies

Ministry of Health

Preventing and controlling MDRO infections at the national level requires collaboration among all types of health-care facilities with MOH. The key functions of the MOH include:

- Leadership and coordination of the national MDRO control strategies and efforts. This includes:
    - Implement a National MDRO Control Program
    - Setting of relevant MDRO related guidelines and quality improvement standards
    - Data collection to monitor progress of the National MDRO Control Program. This includes benchmarking, and ensuring timely feedback of such data to healthcare institutions
    - Utilizing the appropriate accountability platforms to improve performance in MDRO control, antimicrobial management and IPC issues
    - Facilitation of MDRO control, antimicrobial management and IPC related quality improvement initiatives
    - Facilitating the sharing of best practices and initiatives amongst healthcare institutions to accelerate pace and scale of quality improvement
- Conducting national risk assessments and prevalence surveys:

  - A national MDRO risk assessment should be conducted at the minimum annually. More frequent risk assessment should be considered depending on the threat posed by particular MDROs in consultation with experts drawn from healthcare institutions in Singapore. The development of national level MDRO control strategies should in turn be drawn up based on national MDRO risk assessments
  - Periodic national prevalence surveillance should be done to assess efficacy of IPC measures in the national MDRO Control Program
- Developing national antibiograms and conducting epidemiologic investigations if and when necessary
- Conducting targeted regulatory audits to ensure good institutional control:
  - Periodic audits for facility compliance to recommended practices should be done by MOH. Depending on compliance rates, additional educational outreach, such as in-service trainings and webinars, may need to be provided to individual facilities
- Receive escalations and coordinate national responses for novel MDROs, relevant MDRO clusters and MDRO outbreaks (See Escalation and Containment of New MDROs or MDRO Clusters and Outbreaks
- Where appropriate, MOH should also work with other national level regulatory agencies to improve national control of MDROs
- Research activities should be encouraged and supported to determine the best control measures possible.

National Public Health Laboratory

In addition, there must be capabilities at the national level for the following functions to support national MDRO control:

- Molecular epidemiology of MDROs
- Identification or confirmation of emerging or new MDROs e.g. VRSA
- To collect isolates with new or unusual antimicrobial resistance patterns

These capabilities will provide a better understanding of the epidemiology of the specific MDROs and guide national strategies towards better control.

C. Role of Antimicrobial Management in Healthcare Facilities

Appropriate use of antimicrobials has a major role to play in lowering rates of MDROs and preventing selection of further antimicrobial resistance in the healthcare facility. Healthcare facilities should employ a collaborative group of infectious disease physician, pharmacists, microbiologists and IPC personnel to work with heads of departments and clinicians throughout the facility to ensure that there is appropriate and effective management of antimicrobial use for all patient care activities in the healthcare facility. The following interventions for management of antimicrobial usage should be applicable to both acute and long-term care settings, where applicable:

- Restricted formulary as recommended by the facility's Pharmacy and Therapeutics Committee or equivalent committee
- Clinical guidelines on use of antimicrobials for treatment and prophylaxis. Guidelines should be discipline or disease specific. There should be a system in place within the facility to monitor and ensure compliance to such guidelines
- Restricted and appropriate laboratory reporting of antimicrobial susceptibility
- Educational program for MDROs and use of antimicrobials
- Antimicrobial audit and feedback program e.g. antimicrobial stewardship program (ASP)

D. Communication Within and Between Healthcare Facilities

Within Healthcare Facilities

Depending on factors such as patient demography and the types of healthcare services provided, the IPC risk posed by patients with MDROs to the healthcare facility is different from facility to facility.

All healthcare facilities should have the ability to "tag" a patient based on the patient's known MDRO clinical records in accordance to the level of IPC risk posed by patients with the particular MDRO to the healthcare facility. Likewise, all healthcare facilities should have the ability to "untag" a patient when the level of IPC risk posed by a patient when the particular patient's MDRO clinical records suggest that his/her IPC risk has fallen to an acceptable level. Tagging and untagging of MDRO patient in accordance to the level of IPC risk they pose should be done in consultation with the IPC team of the healthcare facility, taking into consideration MDRO clinical record information drawn from clinical/microbiology/laboratory information systems.

The aim of tagging and untagging MDRO patients in accordance to the level of IPC risk is to enable expedient and clear communication of relevant IPC risk information so that other front-line staff ***within*** a healthcare facility can act on this risk information to take the necessary IPC precautions to care for MDRO cases and protect other patients. Tagging and untagging information is NOT for the purposes of informing another healthcare facility.

For example, depending on the healthcare facility, the IPC risk information should be made available to front-line staff such as patient transportation staff, patient registration staff, emergency department staff, bed management staff and clinical staff etc. The IPC risk information should in a form and manner sufficient for the staff to take the appropriate IPC actions promptly. In most instances, only the necessary IPC risk information needs to be communicated to preserve patient confidentiality. The exact MDRO clinical record of the patient should be treated like all other clinical records and should be communicated on a need to know basis e.g. to clinical staff directly involved in the care for the patient.

Between Healthcare Facilities

In order to optimize the care for patients, patient transfer between healthcare facilities may be necessary. Transfers may occur between hospitals, between hospitals and any ILTC facility, or the patient may return home for continued care. Alternatively, patients with MDROs may be discharged from one facility and get re-admitted into another facility in a subsequent healthcare encounter, increasing the risk of an inter-facility transmission. To reduce inter-facility transmission of all MDROs, all healthcare facilities should routinely:

- Communicate up-to-date MDRO clinical records information for patients to be transferred to another facility. Information on the level of IPC risk posed by the MDRO in relation to the *sending* facility may be different from that of the receiving facility and should NOT be communicated to the *receiving* facility
- Receive and act on MDRO clinical records information for patients being admitted to its care. Institutions should ensure that all the necessary staff e.g. front line or admitting staff are able to access MDRO clinical records information, and are trained to respond to the information in the system. This includes tagging the patient appropriately in accordance to the level of IPC risk posed by the MDRO case to the *receiving* healthcare facility

To ensure that MDRO clinical records information communicated between healthcare facilities is clear and effective (contains all necessary information for the receiving institution to decide IPC risk):

- In accordance to recommendations in Chapter 3 Methicillin-resistant *Staphylococcus aureus* (MRSA, Chapter 4 Vancomycin Resistant *enterococcus* (VRE) and Chapter 5 Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE, all the necessary MDRO clinical records in relation to each MDRO should be communicated to enable other healthcare facilities to assess appropriately the level of IPC risk posed by patients with a particular MDRO to their own healthcare settings and proceed to tag or

untag patients in relation to the IPC risk posed to their facility accordingly All healthcare facilities should communicate the patient's up-to-date MDRO clinical records information to other healthcare facilities through a national electronic system

- Changes to a patient's MDRO clinical records should be updated into the national electronic system, as soon as it is known, even after the patient has left the healthcare facility. For example, if a relevant culture result comes back after the patient has left the facility, this information should be updated into the national electronic system
- All healthcare facilities should update a patient's IPC risk profile and proceed to tag or untag a patient within their own facilities based on the latest MDRO clinical records information updated into the national electronic system
- Information on the level of IPC risk posed by the MDRO in relation to the healthcare facility may be different from facility to facility should not be confused with MDRO clinical records information, and should NOT be uploaded into the national electronic system

E. Escalation and Containment of New MDROs or MDRO Clusters and Outbreaks

Escalation to MOH

Escalation of new MDRO cases, clusters* or outbreaks** to MOH in a timely manner is critical should national level assistance or coordination be required to support and/or direct institutional infection control efforts or outbreak investigation. This is especially critical if the healthcare facilities involved have little infection control capabilities. Escalation will also enable a level of national coordination critical to enable other healthcare institutions to undertake the necessary IPC measures, in order to achieve national control.

**Definition of MDRO Cluster: An incident which involves more than the usual number of MDRO cases e.g. more than 2 standard deviations from the monthly mean number of cases for that MDRO, but these cases are either not epidemiologically linked or awaiting epidemiological investigations for confirmation of links*

***Definition of MDRO Outbreak: An incident which involves MDRO cases that are epidemiologically related or that requires ward closure or cancelling of surgery on a significant scale*

Upon the discovery of any of the following scenarios, the IPC team or the microbiology laboratory in the healthcare facility must immediately notify MOH of the situation:

- Any new or emergent MDRO that is *first* identified in the healthcare facility, i.e. never before seen in the healthcare facility concerned. This will ensure that the first case in the country will always be notified to MOH promptly;
- All MDRO cluster (s) or outbreak(s);
- Any collection of MDRO cases occurring within the healthcare facility that are deemed not manageable by the facility;
- Any MDRO cases for which the source is suspected or traced to an iatrogenic or environmental source, which may have implications for other institutions

Notification to MOH should include the following:

- Detailed demographic and clinical information about the MDRO case(s)
- Epidemiologic information about each cluster(s) or the outbreak

Containment and Prevention of Future Clusters or Outbreaks

The ability to contain and prevent future MDRO clusters and outbreaks are the responsibility of healthcare institutions. In the event of a MDRO cluster or outbreak, the healthcare facility must put in

place all necessary infection control interventions to arrest the cluster or outbreak, and must conduct all necessary epidemiological investigations to determine the source of the cluster or outbreak. Such activities must be completed in a timely manner to prevent the situation from worsening and harming more patients. The healthcare facility must work with NPHL, when necessary, to determine if there is clonal spread. Where the cluster or outbreak situation exceeds the infection control or epidemiological capabilities within the facility, it is the responsibility of the institution to inform MOH so that necessary assistance can be mobilized**.**

The healthcare facility must keep MOH updated through the progress of the cluster or outbreak situation through regular epidemiological reports and updates. After the cluster or outbreak has ceased, lessons or gaps in infection control processes, if any, should be identified and steps taken to close gaps to prevent similar future occurrences.

Recurrent Similar Clusters or Outbreaks

The healthcare facility should document and trend recurrent similar clusters or outbreaks and if there are recurrent similar MDRO (> 2 independent) clusters or outbreaks in the facility, the healthcare facility should conduct an aggregate Root Cause Analysis (RCA) to identify the root cause of such reoccurrence, and take all necessary steps to stop such reoccurrence in future.

Chapter 2 Infection Prevention and Control Measures for MDROs in Healthcare Settings

Although transmission of MDROs is most frequently documented in acute care facilities e.g. hospitals, all healthcare settings are affected by the emergence and transmission of antimicrobial-resistant microbes. Successful prevention and control of MDROs requires strong leadership and clinical governance. Healthcare institutions should adopt a continuous quality improvement approach and ensure that the appropriate infection prevention and control strategies are fully implemented. Healthcare institutions should systematically collect IPC data to ensure appropriate feedback to regularly evaluate the effectiveness of IPC strategies. Such data should also be available nationally to provide additional insight into performance of local IPC strategies (See Chapter 1 on National Infection Prevention and Control of MDROs). Strategies should be adjusted such that there is a consistent decrease in the incidence of targeted MDROs. This aim should be to reduce, and where possible, eliminate all patient harm that is caused by MDROs.

The severity and extent of disease caused by these pathogens varies by the population(s) affected and by the healthcare institution(s) in which they are found. Healthcare institutions, in turn, vary widely in physical and functional characteristics, ranging from ILTC facilities to specialty units (e.g., intensive care units [ICU], burn units, neonatal ICUs [NICUs]) in acute care facilities. Accordingly, while the approaches to prevention and control of these pathogens starts from generally applicable interventions such as having infection prevention and control programmes and risk management, these interventions need to be tailored to the specific needs of each population and type of healthcare institution.

A. Infection Prevention and Control Programme and Risk Assessment

An effective IPC programme is essential to control MDROs. IPC programmes must be comprehensive and based upon a clear understanding of the risks, capabilities and capacity, and challenges within each healthcare facility.

All healthcare institutions, whether hospitals or non-acute facilities should have an IPC programme in place, ideally incorporating the following:

- Processes for monitoring infection control problems, including outbreaks of MDROs
- Education of employees in IPC practices
- Processes for development and updating of IPC policies and procedures
- Access to microbiology or laboratory services
- Policies for management of antimicrobial use in the healthcare institution
- Findings of pharmacy and therapeutics reviews and relevant clinical guidelines
- Role of the healthcare facility in national MDRO prevention and control (see Chapter 1 National Infection Prevention and Control of MDROs

Activities to reduce infections from MDROs begin with an assessment of the specific risks in the healthcare facility. When MDROs are introduced into a healthcare facility, a number of factors aid the transmission and persistence of MDROs in the environment. These include:

- Presence of vulnerable patients, such as those with compromised immunity from underlying medical or surgical conditions, those who have indwelling devices including endotracheal tubes, vascular catheters or urinary catheters
- The reservoir of infected or colonised patients
- The selective pressure exerted by antimicrobial use
- The effectiveness of local IPC measures

It is best for all healthcare institutions, whether a hospital or a non-acute facility, to perform an MDRO Risk Assessment annually. Institutions should be familiar with risk assessment principles such as the use of likelihood and impact analyses to support prioritization and action.

Steps to performing an MDRO risk assessment include:

1. Establish the baseline incidence and/or prevalence MDRO rates for the whole healthcare facility or for specific unit(s) in the facility.
2. Identify high-risk populations and/or units based on incidence and/or prevalence rates, local demographic risk data, and known risk factors from scientifically based evidence.
3. Evaluate MDRO data for the facility and/or the specific unit(s) over time to characterize MDRO prevalence or transmission rates to determine if enhanced interventions are needed.
4. Conduct appropriate surveillance for MDROs, taking into account the above risk factors and MDRO data, in order to identify MDRO cases early for infection control.
5. Identify clusters in MDRO transmission in the patient population and/or unit(s) to determine if enhanced interventions are needed.

Based on the institution's MDRO surveillance and risk assessment, the healthcare institution should develop and implement an appropriate IPC programme that targets MDROs in the facility.

This requires each institution to have the following IPC components:

- IPC Department staffing and/or hours assigned to IPC
- Knowledge of IPC interventions current in place in the institution (e.g. Hand Hygiene Programme, Contact Precautions, etc.)
- Status of IPC interventions e.g. measurement parameters and compliance rates
- Comprehensive line list of identified patients with MDROs (colonization and infection)
- Facility antibiogram

Successful implement of an appropriate IPC programme in the healthcare facility is strongly dependent on the availability and timeliness of clinical diagnostic laboratory services. All healthcare institutions should ensure sufficient investment and support for their clinical diagnostic laboratories. Alternatively, resources and support should be available to enable timely access to such services beyond the healthcare facility. Likewise, in order to ensure timely management of clusters and outbreaks, all institutions should ensure that there is either surge capacity within the institution's clinical diagnostic laboratories, or there should be timely access to surge capacity in clinical diagnostic laboratories elsewhere.

In addition, all healthcare institutions should have the ability to mobilize the following resources to support their MDRO Surveillance, Risk Assessment and IPC programme:

- Administrative support
- Facility technical support
- IT support
- Pharmacy capabilities
- Support from the appropriate national agencies e.g. MOH or NPHL

The IPC programme should also detail a definite timeline for implementation, including sufficient time to communicate the IPC programme to all staff for maximum participation. Appropriate monitoring of programme at specific milestones in the timeline should be included to gauge the effectiveness of the IPC programme.

B. Precautionary Measures

In addition to setting up an Infection Prevention and Control Programme and putting in place appropriate risk assessment, precautionary measures are recommended for patients known to be

colonised or infected with MDROs. All healthcare facilities should implement the appropriate interventions described in Appendix 2: Summary of Precautionary Measures for MDRO patients.

MDRO Bundle

Measuring the compliance with precautionary measures on a routine basis will provide the healthcare institution with information on its success in these interventions. For ease of implementation and monitoring, the following precautionary measures may be packaged into an MDRO Bundle:

- Active surveillance
- Antimicrobial management, including antimicrobial stewardship programmes
- Practice of isolation precautions such as contact precautions for patients or residents identified with MDROs
- Hand hygiene in accordance with institutional guidelines
- Environmental hygiene in accordance with institutional guidelines
- Antiseptic body baths (or wipes for bedridden patients or residents) to reduce bio-burden in patients or residents identified with MDROs

Details of the above measures are in Appendix 2: Summary of Precautionary Measures for MDRO patients. Institutional hand hygiene and environmental cleaning guidelines should be developed based on the World Health Organization's (WHO) Five Moments in the WHO Guidelines on Hand Hygiene in Health Care (2009) and the MOH Environmental Cleaning Guidelines for Healthcare Settings (June 2013) respectively.

At least annually, a review of the MDRO Bundle and all other IPC outcomes and process measures will inform whether intensified efforts are needed (see Intensified Interventions to Prevent MDRO Transmission), as well as the areas where improvements can be made.

C. Specific Guidance on Emerging and Endemic MDROs

Emerging MDROs

For emerging MDROs with low prevalence, where the institution's risk assessment requires, the healthcare facilities should:

- Conduct a "Look Back" review of the preceding 6-12 months of microbiology records to detect whether there were any MDRO cases belonging to the emerging type that had gone unrecognized
- If the "Look Back" review identifies any MDRO cases belonging to the emerging type, the facility should perform a point prevalence survey in its high-risk units to determine the burden of MDROs belonging to the emerging type. Examples of high-risk units are ICUs, units with high antimicrobial utilization, as well as the units in which the previously unrecognized cases were identified during the "Look Back" review
- Conduct contact tracing for patients with epidemiologic links to these MDRO cases. The extent of such contact tracing should be determined in discussion with the IPC team of the healthcare facility and may include:
    - Patients within the same cubicle as the MDRO case during the inpatient stay
    - Patients within the same ward as the MDRO case during the inpatient stay, if the situation is such that there is a possibility of transmission across the ward
    - Patients sharing a shared facility with the MDRO case during the inpatient stay, if the situation is such that there is a possibility of transmission through the shared facility e.g. gymnasiums
- Communicate urgently the findings of any previously unrecognized emerging MDRO cases to MOH. Refer to the section on communication (Communication Within and Between Healthcare Facilities

Endemic MDROs

For endemic MDROs, specific interventions may include:

- Conducting active surveillance screening of patients admitted from settings or facilities with high prevalence of MDROs or with risk factors for MDROs
- Consider implementing antiseptic body wash or wipes in an effort to reduce bio-burden till screening specimens are known
- Consider conducting periodic point or period prevalence surveys of MDROs using cultures, to assess efficacy of control interventions
- Monitoring thoroughness of environmental cleaning efforts to ensure consistent environmental cleaning and disinfection of surfaces frequently touched by patients and healthcare personnel (e.g. bedrails, tray table, etc.)

If MDRO rates do not decrease, healthcare facilities should implement intensified interventions to reduce and eliminate transmission (See Intensified Interventions to Prevent MDRO Transmission).

D. Intensified Interventions to Prevent MDRO Transmission

A decision to employ additional MDRO control measures within a healthcare facility may arise from an MDRO Risk Assessment, including a review of surveillance data and assessments of risk to patients, such as when:

- An MDRO is identified in a unit or facility with a highly vulnerable patient population (ICU, NICU, Burns Unit) that had not previously encountered that MDRO i.e. even if the MDRO is identified in just one patient

- There is failure to decrease the prevalence or incidence of MDROs, despite effective implementation of appropriate infection control interventions to limit transmission as well as identification of clusters

A risk assessment of the situation should be carried out along with an evaluation of the measures already in place. Compliance with IPC measures e.g. precautionary measures should be reviewed and correlated with IPC outcomes. This will inform the IPC team where to target intensified efforts and improvement activities. Feedback should also be given to the units and/or wards assessed.

Intensified efforts could include measures such as enhanced education, enhanced surveillance, more stringent environmental cleaning, cohorting and isolation.

E. Infection Prevention and Control Measures for MDRO in Settings Outside of Acute Care Institutions or Facilities

Patients colonised with an MDRO may be encountered in healthcare facilities outside of the acute care institutions or facilities settings such as nursing homes, dialysis centres, and day care or rehabilitation centres. Patient safety and the practice of appropriate IPC is the responsibility of all healthcare institutions. All healthcare facilities, including facilities that are not acute care settings, should have the capabilities and capacity to look after patients should they have MDROs.

No patient should be declined admission to an ILTC facility because of carriage of MDRO. However, strategies should be in place to control the spread of such organisms.

Due to risk assessment, the appropriate IPC guidance differs according to the setting or type of healthcare facility. For example, the isolation of patients in acute care institutions or facilities differs from that for nursing homes because there are more immunocompromised patients and greater use of devices in acute care institutions or facilities. For patients in nursing homes, the nursing home is generally their long-term residence, and isolation for asymptomatic patients who are colonised with MDRO(s) is not indicated.

Alternatively, patients with MDROs may be cared for in their own home or in social homes e.g. homes run by the Ministry of Social and Family Development (MSF).

I. MDRO-colonised Patients in Residential ILTC Facilities and Dialysis Centres

In general, patients colonised with an MDRO do not pose a risk to healthy members of the community (including family members). The management of residents of ILTCs and patients of dialysis centres who are colonised with an MDRO is quite different to that in the acute care setting. When deciding the extent of IPC measures in a residential ILTC facility or dialysis centre, the patient's individual situation, as well as the prevalence of MDROs in the facility, needs to be taken into account. However, all healthcare facilities should endeavour to prevent transmission of MDROs.

Generally:

- Standard precautions should be implemented by all healthcare workers when dealing with all patients in all healthcare facilities regardless of whether they are infected or colonised with an MDRO
- Hand hygiene should be performed in accordance with institutional guidelines, which should be developed based on WHO guidelines
- Contact precautions when managing specific patients should be titrated to the patient's individual situation and the prevalence of MDROs in the institution

The following situations may arise in residential nursing homes or dialysis centres:

A. Relatively healthy independent residents or patients **colonised** with an MDRO:

   Standard Precautions are sufficient, ensuring that gloves and aprons are used when dealing with secretions, draining wounds, stool, ostomy bags or tubes and pressure ulcers.

B. Ill dependent residents/patients OR those with uncontrolled secretions/excretions OR suffering from an **infection** with an MDRO:

Contact Precautions are recommended in this situation. Single room accommodation or treatment is preferable if available. If single rooms are not available, cohorting of residents or patients with the same MDRO is acceptable. If cohorting is not possible, then residents or patients colonised or infected with an MDRO should be placed in a room with other residents or patients considered to be at low risk for acquisition of an MDRO (i.e. not immunocompromised, not on antimicrobials, without open wounds, drains or urinary catheters) or those who have an anticipated short duration of stay.

Other Considerations for Nursing Homes

For the nursing home setting, the implementation of Infection Control precautions at a level required in an acute care setting may have adverse psychological consequences for the nursing home resident, where the facility is also their home. This should be taken into consideration when implementing contact precautions and isolation.

The mobile nursing home resident who is incontinent, confused and/or wandering poses a particular infection control risk when colonised with MDROs. Decisions regarding the best precautions to use for such patients should be made on a case-by-case basis.

If the spread of an MDRO within an ILTC is not controlled by the Infection Control precautions mentioned above, intensified infection control measures may be required and expert advice should be sought.

II. MDRO-colonised Patients in Non-Residential ILTC Facilities (Excluding Dialysis Centres) and Other Ambulatory Care Settings

Although the risk of MDRO transmission is lesser in non-residential ILTC facilities and ambulatory care settings e.g. day care centres, these facilities must also have capabilities to manage patients with MDROs.

Basic IPC measures apply to prevent possible spread of healthcare associated infections. There must be easy access to hand hygiene facilities, for example sink or alcohol hand rub, for healthcare workers to use during patient care practices. Each facility should develop policies and procedures on environmental hygiene. Where possible, MDRO-colonised patients should be scheduled separately for their sessions. If not feasible, all items used and environmental surfaces should be disinfected immediately between patients (refer to MOH Environmental Cleaning Guidelines).

Other Aspects of Control of MDRO for All ILTCs and Ambulatory Settings

These include:

- Pre-admission review of referrals for MDROs so that appropriate precautions can be prepared before patients' arrival at institution
- Active surveillance, if the ILTC or ambulatory facility's IPC risk assessment requires, should be conducted upon the arrival of the patient or resident. Pending the results of active surveillance, appropriate precautions should be undertaken by the healthcare facility
- Maintaining a list of residents infected or colonised with an MDRO (refer to Chapter 3 Methicillin-resistant *Staphylococcus aureus* (MRSA, Chapter 4 Vancomycin Resistant *enterococcus* (VRE), Chapter 5 Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE)

- Monitoring MDRO culture results of specimens sent to the local microbiology laboratory, if any
- Communication of information relating to the MDRO Clinical Records Information of a MDRO colonised resident or patient to other receiving or transmitting facilities, such as upon referral to the hospital or other healthcare facilities
- Ensuring adequate environmental cleaning

III. MDRO-colonised Persons at Home or in Social Homes

Standard Precautions including hand hygiene should be implemented. Single-use person care equipment should be used where possible. Where possible, dedicated person care equipment should be used which should remain in the person's home until they are discharged from the home-care service. Where equipment cannot be left in the person's home (e.g. stethoscopes) or not designated as single person use, they should be cleaned and disinfected using a low to intermediate level disinfectant before leaving the person's home. Alternatively, the item of equipment should be placed in a plastic bag for transport to another site for cleaning and disinfection.

References:

1. CDC, Healthcare Infection Control Practices Advisory Committee. Management of multi-drug-resistant organisms in healthcare settings, 2006. Atlanta, GA: US Department of Health and Human Services, CDC, Healthcare Infection Control Practices Advisory Committee; 2007. Available at http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroguideline2006.
2. Merrer J, Santoli F, Appere de Vecchi C, Tran B, De Jonghe B, and Outin H. "Colonization pressure" and risk of acquisition of methicillin-resistant *Staphylococcus aureus* in a medical intensive care unit. *Infect Control Hosp Epidemiol* 2000; 21: 718-723.
3. D'Agata EM, *et al*. High rate of false-negative results of the rectal swab culture method in detection of gastrointestinal colonization with vancomycin resistant enterococci. *Clin Infect Dis* 2002; 34: 167-172.
4. Muto CA, Jernigan JA, Ostrowsky BE, Richet HM, Jarvis WR, Boyce JM *et al*. SHEA guideline for preventing nosocomial transmission of multi-drug-resistant strains of *Staphylococcus aureus* and enterococcus. *Infect Control Hosp Epidemiol* 2003; 24(5): 362-386.
5. Pittet D, Hugonnet S, Harbarth S, *et al*. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. *Lancet* 2000; 356:1307-1312.
6. Coia JE, Duckworth GJ, Edwards DI, Farrington M, Fry C, Humphreys H, Mallaghan C, Tucker DR, for the Joint Working Party of the British Society of Antimicrobial Chemotherapy, the Hospital Infection Society, and the Infection Control Nurses Association. Guidelines for the control and prevention of meticillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. *J Hosp Infect* 2006; 63S: S1-S44
7. Larson EL. APIC guideline for handwashing and hand antisepsis in health care settings. *Am J Infect Control1995*; 23: 251-269.
8. World Health Organisation. WHO Guidelines on Hand Hygiene in Healthcare. 2009. 12-5-2010. Ref Type: Internet Communication
9. Cookson BD, Macrea MB, Barrett SP, Brown DFJ, Chadwick C, French GL, Hately P, Hosein IK, Wade JJ Guidelines for the control of glycopeptide-resistant enterococci in hospitals. *J Hosp Infect* 2006; 62:6-21

10. Gopal Rao G, Jeanes A. A pragmatic approach to the use of isolation facilities. *Bugs Drugs* 1999;5: 4-6
11. Auckland C, Pallet A, Smith J (2002) Use of adult isolation facilities in a UK infectious diseases unit. *J Hosp Infect* 52(1): 74–5
12. Jeanes A, Macrae B, Ashby J. Isolation Prioritisation tool: revision, adaptation and application. *British Journal of Nursing* 2011; 20 (9): 540-544
13. From the Public Health Service US Department of Health and Human Services Centres for Disease Control and Prevention Atlanta Georgia. Siegel JD, Rhinehart E, Jackson M, Chiarello L and the Healthcare Infection Control Practices Advisory Committee; US Department of Health and Human Services Centres for Disease Control and Prevention. Guideline for Isolation precautions: Preventing Transmission of Infectious Agents in Healthcare Settings 2007.
14. Centers for Disease Control and Prevention. Guidance for control of infections with carbapenem-resistant or carbapenemase-producing *Enterobacteriaceae* in acute care facilities *Morbid Mortal Weekly Rep* 2009; 58(10); 256-26
15. CDC (2003) *MMWR* 52(RR10);1-42.
16. CDC (1995) *MMWR Recomm Rep* 44 (RR-12), 1-13.
17. Woodhead K, Taylor EW, Bannistir G, Chesworth T, Hoffman P, Humphreys H. A report from the Hospital Infection Society Working Party on Infection Control in operating theatre. Behaviour and rituals in the operating theatre. *J Hosp Infect* 2002; 51: 241-55
18. Burns K, Schaffer K on behalf of the SARI subcommittee for the development of guidance for the prevention of multi-drug resistant organisms. CRE update issued on laboratory detection and infection control measures. Epi-insight vol.12 isssue 5 May 2011
19. Smith Philip W, Bennett, Gail et al. SHEA /APIC Guideline: IPC in the Long-term Care Facility *Am J Infect Control* 2008:36: 504-535

Chapter 3 Methicillin-resistant *Staphylococcus aureus* (MRSA)

Although there are many MDROs that cause patient infections, methicillin-resistant *Staphylococcus aureus*, commonly referred to as MRSA, is one of the most prevalent and persistent. All healthcare institutions should have a programme to monitor MRSA infections. All healthcare institutions should implement the MDRO Bundle so has to reduce MRSA infections. The MDRO bundle is mentioned in Chapter 2.

A. Active Surveillance Cultures for MRSA in Acute Care Institutions or Facilities

Active surveillance cultures help to identify colonised MRSA patients in a facility or in a specific unit. This is recommended for all acute care institutions or facilities in Singapore. Patient population groups with known low risk factors for MRSA colonisation e.g. psychiatric, paediatric and obstetric patients may be exempted from active surveillance.

B. Active Surveillance for MRSA in Residential ILTCs

The purpose of active surveillance for MRSA in residential ILTCs is to determine incidence and/or prevalence of MRSA in the facility. Additionally, this could be used to evaluate the success of an intervention that was implemented in response to increased MRSA infections or a MRSA outbreak.

Examples of short-term MRSA Active Surveillance programs include:

- Determining incidence or prevalence for the facility or for a particular unit or services
- Getting a baseline MRSA determination for a facility risk assessment
- During implementation of a process change (i.e., opening a new service or facility)
- During implementation of an intervention developed to reduce MRSA rates

C. Bed management of MRSA patients in Acute Care Institutions or Facilities

Each hospital should develop an appropriate bed management and prioritisation policy that is based on the institution's IPC risk assessment. For example, different MDROs may require a different priority in terms of isolation rooms in the healthcare facility. This should be done in consultation with the healthcare facility's IPC team.

D. Management of MRSA Patients in ILTCs

No patient should be declined admission to an ILTC because of carriage of MRSA. However, protocols should be in place to control the spread of MRSA in the ILTCs. For detailed management of MRSA carriers in ILTCs, refer to Infection Prevention and Control Measures for MDRO in Settings Outside of Acute Care Institutions or Facilities.

E. MRSA Clinical Information Records and Criteria for Tagging and Untagging MRSA Cases

MRSA Clinical Information Records

The MRSA Clinical Information Records to be shared across healthcare institutions for any patient includes the following information:

- All MRSA positive microbiology result [screening, culture or, PCR result etc] within the last 2 years from the date of request, including the date of test, the specimen type and the laboratory that performed the test.
- All MRSA screening results (including positive and negative) within the last 2 years from the date of request, including the date of test and the laboratory that performed the test.

Tagging and Untagging of MRSA

The criteria for tagging and untagging of MRSA cases should be based on the IPC risk posed by patients with a particular MRSA Clinical Information Records in relation to the particular healthcare facility concerned (see Communication Within and Between Healthcare Facilities

Such a risk differs from healthcare facility to healthcare facility. As such, tagging and untagging of MRSA cases should be done in consultation with the IPC team in charge of the healthcare facility. Tagging and untagging should be conducted in a timely manner upon ascertainment of MRSA Clinical Information Records so that appropriate and timely IPC measures can be implemented.

MRSA Tagging for Acute Care Institutions or Facilities

An acute care institution or facility should tag all patients who are found to be MRSA positive.

MRSA Untagging for Acute Care Institutions or Facilities

An acute care institution or facility can consider untagging patients with a past history of MRSA positivity, if the patient has either:

- Undergone decolonisation with Chlorhexidine bath or Octenidine wash and Mupirocin nasal cream for at least 5 days is completed in any healthcare facility OR
- 3 negative screening culture from nasal, axillae and groin (NAG), with first sample at least 1 week after completion of decolonisation therapy

Or if no decolonisation, the patient in an acute care institution or facility setting must meet one of the following criteria:

- More than 2 years since the last positive culture
- 3 negative NAG screening cultures (at least 1 day apart)

F. Specific Data Collection and Reporting Requirements for MRSA

The national reporting requirements for MRSA are detailed in Appendix 7: Data Collection and Reporting Requirements for MDROs.

Chapter 4 Vancomycin Resistant *enterococcus* (VRE)

VRE was first recognised in large numbers in an acute hospital in 2005 and remained at relatively low levels until 2010. Since then, the numbers have steadily increased in acute care hospitals and may already be present in the ILTCs. Acute care institutions or facilities with low prevalence for VRE should aim to keep the rates low with stringent policies on surveillance, isolation or cohorting. Acute care institutions or facilities with higher prevalence or are endemic for VRE should still have measures to contain VRE and avoid increased transmission.

A. Infection Control Measures

Active Surveillance for VRE

Screening patients for rectal carriage of VRE using active surveillance increases VRE detection rates approximately three-fold above detection rates from clinical specimens alone. Most studies reporting on the use of active surveillance cultures have used these in combination with other Infection Control interventions.

Active surveillance is recommended for dialysis patients and patients admitted to high-risk units, ICU, haematology or oncology and transplantation.

B. Criteria for Isolation for Patients with VRE in Acute Care Institutions or Facilities

Patients diagnosed with VRE should preferably be isolated or cohorted. In situations where patient numbers exceed isolation capacity, they may be kept in general wards and nursed with Contact Precautions.

C. Removal from Isolation or Cohorting of Patients in Acute Care Institutions or Facilities

For acute care institutions or facilities with low levels of VRE prevalence, e.g. lower than 2 standard deviations of the national rate, there is no indication to remove from isolation during admission.

D. VRE Clinical Information Records and Criteria for Tagging and Untagging VRE Cases

VRE Clinical Information Records

The VRE Clinical Information Records to be shared across healthcare institutions for any patient includes the following information:

- All VRE positive microbiology result [screening, culture or, PCR result etc] within the last 2 years from the date of request, including the date of test, the specimen type and the laboratory that performed the test
- All VRE screening results (including positive and negative) within the last 2 years from the date of request, including the date of test and the laboratory that performed the test

Tagging and Untagging of VRE

The criteria for tagging and untagging VRE cases should be based on the VRE Clinical Records Information of the patient (see Communication Within and Between Healthcare Facilities

Tagging and untagging of VRE cases should be based on the IPC risk posed by patients with a particular VRE Clinical Records Information in relation to the particular healthcare facility concerned. Such a risk differs from healthcare facility to healthcare facility. As such, tagging and untagging of VRE cases should be done in consultation with the IPC team in charge of the healthcare facility.

Tagging and untagging should be conducted in a timely manner upon ascertainment of VRE Clinical Records Information so that appropriate and timely IPC measures can be implemented.

VRE Tagging for Acute Care Institutions or Facilities

An acute care institution or facility should tag all patients who are found to be VRE positive via laboratory culture.

VRE Untagging for Acute Care Institution or Facility

An acute care institution or facility can consider untagging patients with a past history of VRE positivity, if the patient has either:

- More than 2 years since the last positive culture OR
- 3 negative rectal screening cultures (at least 1 month apart)

E. Management of VRE patients in ILTCs

No patient should be declined admission to an ILTC because of carriage of VRE. However, protocols should be in place to control the spread of VRE in the ILTCs. For detailed management of VRE carriers in ILTCs, refer to Infection Prevention and Control Measures for MDRO in Settings Outside of Acute Care Institutions or Facilities.

F. Specific Data Collection and Reporting Requirements for VRE

The national reporting requirements for VRE are detailed in Appendix 7: Data Collection and Reporting Requirements for MDROs.

References

1. Recommendations for Preventing the Spread of Vancomycin Resistance Recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC) *MMWR* 1995; 44(RR12): 1-13
2. Public Health Agency of Canada, Infection Control Guidelines. Preventing the Spread of Vancomycin-Resistant Enterococci (VRE) in Canada. 1997

Chapter 5 Carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE)

A. Background

Enterobacteriaceae is a term used to describe groups of Gram-negative bacilli that commonly live in the enteric tract or bowel and includes organisms such as *Escherichia coli (E. coli)*, *Klebsiella pneumonia (K. pneumoniae)*, *Enterobacter cloacae*, and *Citrobacter freundii*. β lactam antimicrobials comprise some of the most commonly used agents, such as penicillins, cephalosporins, monobactams and carbapenems. The production of enzymes known as β lactamases by *Enterobacteriaceae* is a key mechanism for the development of resistance to the various types of β-lactam antimicrobials. Today, many β lactamases exist, including extended spectrum β lactamases (ESBL), AmpC β lactamases and carbapenemases. These enzymes have varying spectra of hydrolytic activity, and are frequently located on mobile genetic elements, known as plasmids enhancing their transmissibility between bacteria including different species.

There are two major forms of carbapenem resistance in *Enterobacteriaceae:*

- The production of a broad-spectrum β lactamase enzyme (carbapenemase) that cleaves the carbapenem antimicrobial rendering it irreparably damaged and ineffective. The gene coding for the enzyme production is found on plasmids
- The combination of broad-spectrum β lactamase (ESBL or AmpC) production with decreased permeability of the bacterial cell wall for the antimicrobial due to porin loss

It is this first group that is emerging rapidly now and is of particular concern and are referred to as CP-CREs. The most commonly encountered CP-CREs are:

- *Klebsiella pneumoniae* carbapenemase (KPC)
- New Delhi metallo-β-lactamase (NDM)

- Oxacillinase (OXA)
- Others such as Verona Integron-encoded metallo-β-lactamase (VIM) and Imipenemase Metallo-beta-lactamase (IMP)

In Singapore, CP-CREs were first recognized in 2011. In 2012, 70 cases were identified, of which 62 were clinical specimens and 8 were identified via contact tracing. This chapter aims to provide guidance on a national approach to control or slow down the increasing prevalence of CP-CRE in Singapore.

B. Risk Factors and Mode of Transmission

Common risk factors for acquisition of carbapenem-resistant *Enterobacteriaceae* include:

- Exposure to broad-spectrum antimicrobials, such as cephalosporins, β lactam-β lactamase inhibitor combinations, fluoroquinolones
- Prolonged or recurrent hospitalisation
- ICU admission
- Presence of central vascular catheters
- Long term urinary catheterisation

Carriage of carbapenem-resistant *Enterobacteriaceae* can be identified on or during admission. The gastrointestinal tract is the most likely site for asymptomatic colonisation with carbapenem-resistant *Enterobacteriaceae* in patients. In one report, only two of 14 patients with gastrointestinal colonisation of CP-CRE had positive cultures for CP-CRE from clinical samples. Hence, active surveillance cultures for rectal carriage of CP-CRE can increase the detection rate, although the sensitivity of rectal surveillance swabs has not been determined.

Contaminated hands of healthcare workers have been implicated in hospital outbreaks due to carbapenem-resistant *Enterobacteriaceae*. There is no evidence that rectal colonisation of healthcare workers contributes to transmission. Although carbapenem-resistant *Enterobacteriaceae* have been detected in the hospital environment, the role of environmental contamination in hospital outbreaks has been less defined in comparison to VRE.

C. Clinical Significance

There are almost no therapeutic options for the treatment of infections caused by carbapenem-resistant *Enterobacteriaceae* as these organisms are often resistant to other classes of antimicrobials such as aminoglycosides and fluoroquinolones. Carbapenems are currently the β-lactams of choice for the treatment of serious infections caused by ESBL and AmpC-producing organisms, but the increasing reliance on carbapenems for the treatment of infections by these organisms adds to the selective pressure for the emergence of carbapenem resistance. Options for treatment of CP-CRE infections include tigecycline, fosfomycin and polymixin B but, non-susceptibility or resistance to these antimicrobials is increasingly reported.

Infections caused by resistant *Enterobacteriaceae* are associated with significantly increased risk of mortality. Mortality rates associated with infections caused by CP-CRE range from 38-57%.

D. Infection Control and Prevention Measures for CP-CRE

The limited therapeutic options for infections by carbapenem-resistant *Enterobacteriaceae*, as well as their propensity for spread underscore the importance of active surveillance and infection control measures. Patients with non CP-CRE should preferably be isolated if isolation facilities are available.

Patients with unrecognised carriage of CP-CRE can serve as reservoirs enabling cross-transmission and therefore, healthcare-associated infections and outbreaks.

Active surveillance is recommended for high-risk patient groups (see Risk Factors and Mode of Transmission). Each healthcare facility should have an active surveillance programme with the methods factoring in local work flows and the quantum of the surveillance linked to the nature of the hospital, restructured hospitals being more active.

E. Laboratory Identification of CP-CRE in Screening Samples

Identification of all CP-CRE cases should be timely to allow appropriate infection control measures and contact tracing to commence within 3 working days following its initial identification as a CRE case.

Rectal swab or faeces is the recommended specimen for the purpose of surveillance for resistant *Enterobacteriaceae*. Specimens taken from other sites (e.g. urine, swabs from skin breaks or manipulated sites) may also be suitable for surveillance purposes.

When a CP-CRE isolate with confirmed carbapenemase production has been detected from a clinical specimen on a ward or unit, surveillance screening by a rectal swab is recommended for patients with epidemiological links (as defined by an individual institution) to the index case.

Patients should be informed of their positive status for colonisation or infection with CP-CRE and provided with an information leaflet.

Clinical teams have the trust of the patient and the family members of patients under their care. As such, the responsibility of informing patients of their MDRO colonisation status lies primarily with the clinical team caring for the patient during their in-patient stay. Clinical teams must be apprised of these guidelines on MDRO management and must balance patient preferences and patient care

considerations versus national public health considerations in order to achieve national control of MDROs. They should have access to infection control experts on CP-CRE within their facility or regional health system.

F. CP-CRE Clinical Records Information and Criteria for Tagging and Untagging CP-CRE Cases

CP-CRE Clinical Records Information

The CP-CRE Clinical Records Information for any patient includes the following information:

- All CP-CRE positive microbiology result [screening, culture or, PCR result etc] within the last 2 years from the date of request, including the date of test, the specimen type and the laboratory that performed the test
- All CP-CRE screening results (including positive and negative) within the last 2 years from the date of request, including the date of test and the laboratory that performed the test

Tagging of CP-CRE

The criteria for tagging CP-CRE cases should be based on the CP-CRE Clinical Records Information of the patient (see Communication Within and Between Healthcare Facilities
). Tagging of CP-CRE cases should be based on the IPC risk posed by a particular CP-CRE Clinical Records Information in relation to the particular healthcare facility concerned. Such a risk differs from healthcare facility to healthcare facility. As such, tagging of CP-CRE cases should be done in consultation with the IPC team in charge of the healthcare facility. Tagging should be conducted in a timely manner upon ascertainment of CP-CRE Clinical Records Information so that appropriate and timely IPC measures can be implemented.

CP-CRE Tagging for Acute Care Institution or Facilities

An acute care institution or facility should tag all patients who are found to be positive for any CP-CRE via laboratory tests.

CP-CRE Untagging for Acute Care Institution or Facility

All CP-CRE cases should not be untagged.

G. Infection Control Recommendations for the Acute Care Institution or Facility Setting

At the minimum, for acute care institutions or facilities, the institution or facility's surveillance programme for CP-CRE shall consist of any patient with any one of the following:

- Risk factors identified based on the hospitals' epidemiological data
- History of hospitalisation overseas within the past 1 year
- History of hospitalisation locally in a private hospital with the past 1 year[1]

All acute care institution or facility should have a policy for contact tracing of all CP-CRE cases. The minimum standard for contact tracing shall be all existing inpatients who were in the same cubicle of the index case from time the case was admitted.

All CP-CRE cases should be notified to MOH. The patient surveillance form should be completed for each patient when CP-CRE is confirmed (Appendix 7: Data Collection and Reporting Requirements for MDROs).

[1] Shall not apply to any private hospital if the patient is being readmitted i.e. the patient has a history of admission to the private hospital concerned within the past 1 year

CP-CRE patients in acute care institutions or facilities should be isolated in single rooms with *en-suite* toilet facilities using Contact Precautions. Provision for separate use of equipment and facilities should be arranged. Amongst other cases requiring Contact Precautions, the priority should be given to patients with CP-CRE. Healthcare workers should wear long-sleeved gowns if physical contact with the patient is anticipated.

There is insufficient evidence on decolonization regimens for resistant *Enterobacteriaceae*. Attempts to decolonise patients are not recommended.

H. Infection Control Recommendations for Settings Outside Acute Care Institutions or Facilities

No patient should be declined admission to an ILTC because of carriage of CP-CRE. However, protocols should be in place to control the spread of CP-CRE in the ILTCs. For detailed management of CP-CRE carriers in ILTCs, refer to Infection Prevention and Control Measures for MDRO in Settings Outside of Acute Care Institutions or Facilities.

I. Nursing Homes

CP-CRE patients should be placed in a single room or cohorted with other CP-CRE patients. If cohorting is not possible, then those residents colonised or infected with CP-CRE should be placed in a room with residents considered to be at low risk for acquisition of an MDRO (i.e. not immunocompromised, not on antimicrobials, without open wounds, drains or urinary catheters) or those who have an anticipated short duration of stay. If not feasible, they can be nursed with contact precaution in a corner bed, separated from high-risk patients. There should also be stringent infection control and environmental cleaning.

For CP-CRE patients who require total care or who have draining wounds or faecal or urinary

incontinence or uncontrolled secretions, use Contact Precautions:

- Wear gloves when touching the patient's intact skin or surfaces and articles in close proximity to the patient. Don gloves upon entry into the room
- Wear a gown whenever anticipating that clothing will have direct contact with the patient or potentially contaminated environmental surfaces or equipment in close proximity to the patient. Don gown upon entry into the room. Remove gown and wash hands before leaving the patient-care environment
- After gown removal, assure that clothing does not contact patient or patient care environment
- Do not share equipment between patients. If equipment such as glucometers must be shared, carefully disinfect the equipment between patients, following manufacturer's guidelines

For CP-CRE patients who are mainly independent, staffs are to follow Standard Precautions, i.e. to use gloves and gowns for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence and ostomy tubes or bags. These patients may be allowed to ambulate and socialize based on their ability to observe proper hand hygiene and contain their secretions and excretions.

If a patient is put under Contact Precautions, hands are to be cleaned before putting on gowns and gloves. Gowns and gloves are to be discarded immediately after removal inside the patient room before exiting. Hands are to be cleaned with alcohol based hand rub after removing gowns and gloves. Whilst removing gowns and gloves, staffs are to take care not to contaminate the patient care environment.

If patients are cohorted, a clean gown and gloves are to be used between patients.

J. Specific Data Collection and Reporting Requirements for CP-CRE

The national reporting requirements for CP-CRE are detailed in Appendix 7: Data Collection and Reporting Requirements for MDROs.

References

1. Walsh TR. Clinically significant carbapenemases: an update. *Curr Opin Infect Dis* 2008; 21: 367-371
2. Meyer E, Serr A, Schneider C, Utzolino S, Kern WV, Scholz R, Dettenkofer M. Should we screen patients for extended-spectrum b-lactamase-producing *Enterobacteriaceae* in Intensive Care Units? *Infect Control Hosp Epidemiol* 2009; 30: 103-105
3. Kumarasamy KK, Toleman MA, Walsh TR, *et al*. Emergence of a new antimicrobial resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study. *Lancet Infect Dis* 2010; 10: 597-602.
4. Nordmann P, Cuzon G, Naas T. The real threat of *Klebsiella pneumoniae* carbapenemase-producing bacteria. *Lancet Infect Dis* 2009; 9: 228-236.
5. Grundmann H, Livermore DM, Giske CG, *et al*. Carbapenem-non-susceptible *Enterobacteriaceae* in Europe: conclusions from a meeting of national experts. *Euro Surveill* 2010; 15(46): pii=19711.
6. Schwaber MJ, Klarfeld-Lidji S, Navon-Venezia S, *et al*. Predictors of carbapenem-resistant *Klebsiella pneumoniae* acquisition among hospitalized adults and effect of acquisition on mortality. *Antimicrob Agents Chemother* 2008; 52: 1028-1033.
7. Bratu S, Mooty M, Nichani S, *et al*. Emergence of KPC-possessing *Klebsiella pneumoniae* in Brooklyn, New York: epidemiology and recommendations for detection. *Antimicrob Agents Chemother* 2005; 49: 3018-3020.
8. Kochar S, Sheard T, Sharma R, *et al*. Success of an infection control program to reduce the spread of carbapenem-resistant *Klebsiella pneumoniae*. *Infect Control Hosp Epidemiol* 2009; 30(5): 447-452.
9. Schwaber MJ, Lev B, Israeli A, *et al*. Containment of a country-wide outbreak of carbapenem-resistant *Klebsiella pneumoniae* in Israeli hospitals via a nationally implemented intervention. *Clin Infect Dis* 2011; 52: 848-855.
10. Leverstein-Van Hall MA, Stuart JC, Voets GM, Versteeg D, Tersmette T, Fluit AC. Global spread of New Delhi metallo-β-lactamse 1. *Lancet Infect Dis* 2010; 10: 83-831

11. Dashti AA, Jadaon MM, Gomaa HH, Noronha B, Udo EE. Transmission of *Klebsiella pneumoniae* clone harbouring genes for CTX-M-15-like and SHV-112 enzymes in a neonatal intensive care unit of a Kuwaiti hospital. *J Med Microbiol* 2010; 59: 687-692
12. Pessoa-Silva CL, Meurer Moreira B, Camara Almeida V, Flannery B, Almeida Lins MC, Mello Sampaio JL, Martins Teixeira L, Vaz Miranda LE, Riley LW, Gerberding JL. Extended-spectrum β-lactamase-producing *Klebsiella pneumoniae* in a neonatal intensive care unit: risk factors for infection and colonization. *J Hosp Infect* 2003; 53: 198-206
13. Marchaim D, Chopra T, Pogue JM, *et al*. Outbreak of colistin-resistant, carbapenem-resistant *Klebsiella pneumoniae* in Metropolitan Detroit, Michigan. *Antimicrob Agents Chemother* 2011; 55: 593-599.
14. Carmeli Y, Akova M, Cornaglia G, *et al*. Controlling the spread of carbapenemase-producing Gram-negatives: therapeutic approach and infection control. *Clin Microbiol Infect* 2010; 16: 102-111.
15. Miriagou V, Cornaglia G, Edelstein M, *et al*. Acquired carbapenemases in Gram-negative bacterial pathogens: detection and surveillance issues. *Clin Microbiol Infect* 2010; 16: 112-122.
16. Health Protection Agency (HPA). Advice on carbapenemase producers: recognition, infection control and treatment. www.hpa.org.uk; 31/01/2011.
17. Centers for Disease Control and Prevention (CDC). Guidance for control of infections with carbapenem-resistant or carbapenemase-producing *Enterobacteriaceae* in acute care facilities. *MMWR Morb Mortal Wkly Rep* 2009: 58(10): 256-260.
18. Ben-Ami R, Schwaber MJ, Navon-Venezia S, Schwartz D, Giladi M, Chmelnitsky I, Leavitt A, Carmeli Y. Influx of extended-spectrum β-lactamase-producing *Enterobacteriaceae* into the hospital. *Clin Infect Dis* 2006; 42: 925-934
19. Ben-David D, Maor Y, Keller N, *et al*. Potential role of active surveillance in the control of a hospital-wide outbreak of carbapenem-resistant *Klebsiella pneumoniae* infection. *Infect Control Hosp Epidemiol* 2010; *31*: 620-626.

20. Endimiani A, Depasquale JM, Forero S, Hujer AM, Roberts-Pollack D, Fiorella PD *et al*. Emergence of *bla* KPC-containing *Klebsiella pneumoniae* in a long-term acute care hospital: a new challenge to our healthcare system. *J Antimicrob Chemother* 2009; 64:1102-10.
21. Overturf, G. Carbapenemases: A brief review for pediatric infectious disease specialists. *Pediatr Infect Dis J* 2010; 29:68-70.
22. Castanheira M, Deshpande LM, Mathai D, Bell JM, Jones RN, Mendes RE *et al*. Early dissemination of NDM-1- and OXA-181-producing *Enterobacteriaceae* in Indian hospitals: report from the SENTRY Antimicrobial Surveillance Program, 2006-2007. *Antimicrob Agents Chemother* 2011; 55:1274-8.
23. Kumarasamy KK, Toleman MA, Walsh TR, Bagaria J, Butt F, Balakrishnan R *et al*. Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study. *Lancet Infect Dis* 2010; 10:597- 602.
24. Nordmann P, Poirel L, Walsh TR, Livermore DM. The emerging NDM carbapenemases. *Trends Microbiol* 2011; 19: 588-95.
25. Walsh TR, Weeks J, Livermore DM, Toleman MA. Dissemination of NDM-1 positive bacteria in the New Delhi environment and its implications for human health: an environmental point prevalence study. *Lancet Infect Dis* 2011; 11:355-62.
26. Poirel L, Potron A, Nordmann P. OXA-48-like carbapenemases: the phantom menace. J *Antimicrob Chemother* 2012; 67: 1597-606.
27. Giani T, Conte V, Di Pilato V, Aschbacher R, Weber C, Larcher C *et al*. *Escherichia coli* from Italy producing OXA-48 carbapenemase encoded by a novel Tn1999 transposon derivative. *Antimicrob Agents Chemother* 2012; 56: 2211-3.
28. Lartigue MF, Poirel L, Poyart C, Réglier-Poupet H, Nordmann P. Ertapenem resistance of *Escherichia coli*. *Emerg Infect Dis* 2007; 13: 315-7.
29. Doumith M, Ellington MJ, Livermore DM, Woodford N. Molecular mechanisms disrupting porin expression in ertapenem-resistant *Klebsiella* and *Enterobacter* spp. clinical isolates from the UK. *J Antimicrob Chemother* 2009; 63:659-67.

30. Centers for Disease Control and Prevention (CDC). Guidance for control of infections with carbapenem-resistant or carbapenemase-producing *Enterobacteriaceae* in acute care facilities. *MMWR Morb Mortal Wkly Rep* 2009; 58:256-60.
31. Centers for Disease Control and Prevention (CDC). Guidance for Control of Carbapenem-resistant *Enterobacteriaceae* 2012 CRE Toolkit. Available from: http://www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf (Last accessed on September 17th 2012).

Appendix 1: Definitions and Abbreviations Used in the Document

Definitions

Multi-drug resistant organism (MDRO): The term multi-drug resistance as used in these guidelines describes a bacterial isolate which is resistant to one or more agents in three or more different classes of antimicrobials that the isolate is expected to be susceptible to; e.g., penicillins, cephalosporins, aminoglycosides, fluoroquinolones and carbapenems.

Active Surveillance: This is a process to identify MDRO carriers using microbiological tests (culture or PCR) at time of admission with the objective to institute prompt infection control measures. This could be done either as universal or as targeted active surveillance. Universal active surveillance refers to the screening of all patients or residents on admission for carriage of specific MDRO. In contrast, targeted active surveillance refers to screening of patients or residents according to risk factors.

Infection: The presence of MDRO in tissues or body fluids along with signs and symptoms of infection (either locally or systemically) or the presence of MDRO in normally sterile body sites or fluids (usually but not necessarily with symptoms of infection).

Colonisation: The presence of MDRO in body fluids or tissues (e.g., gastrointestinal tract, urine, or sputum) without clinical signs of infection.

Acute Care Institutions or Facilities: These refer to public and private hospitals, including community hospitals.

ILTC Facilities: These refer to all intermediate and long term health care facilities, whether these are residential or non-residential. For example, ILTC healthcare facilities include Nursing Homes,

Dialysis Centres and Day Rehabilitation Care settings. ILTC healthcare facilities do not include non-healthcare facilities such as homes under the Ministry of Social and Family Development (MSF). ILTC healthcare facilities do not include Ambulatory Healthcare Facilities.

Non-Residential ILTC Facilities and Ambulatory Care Setting: These refer to settings such as polyclinics, specialist outpatient clinics, General Practitioner clinics in the community, physiotherapy centres, as well as outpatient day rehabilitation centres.

Social Homes: These refer to residential homes in Singapore that are managed by the Ministry of Social and Family Development. The range of homes includes Sheltered Homes and Destitute Homes and others.

Emerging MDROs

- Carbapenemase producing carbapenem resistant *Enterobacteriaceae* (CP-CRE)
- Vancomycin-resistant *Staphylococcus aureus* (VRSA)

Endemic MDROs

- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Multi-resistant *Pseudomonas species*
- Multi-resistant *Acinetobacter* species
- Vancomycin-resistant *Enterococcus* (VRE)

MDRO Clinical Records Information: This refers to a national electronic record system consisting of patients' multi-drug resistant organism (MDRO) laboratory results to help clinical management decisions.

Abbreviations

BSI: Bloodstream infection

CDC: Centre for Disease Control

HDU: High Dependency Unit

HICPAC: Hospital Infection Control and Prevention Advisory Committee

ICU: Intensive Care Unit

IPC: Infection prevention and control

MDRO: Multidrug-resistant organism

NHSN: National Healthcare Safety Network

NICU: Neonatal Intensive Care Unit

PPE: Personal protective equipment

WHO: World Health Organisation

Appendix 2: Summary of Precautionary Measures for MDRO patients

A. ***Patient placement***

- Patients known to be colonised or infected with a Multidrug-resistant Organism (MDRO) that is newly emerging (e.g. carbapenemase-producing carbapenem resistant *Enterobacteriaceae* [CP-CRE]) should be admitted to a single room where possible, where gown and gloves are to be used as PPE. Cohorted patients in general wards are to be cohorted with patients with the same MDROs; with emphasis on hand hygiene practices by both staffs and visitors. Patients with diarrhoea or incontinence are at a higher risk of spreading MDRO known to colonise the intestinal tract (e.g. vancomycin-resistant *enterococcus* [VRE], CP-CRE) and should be given priority for single rooms. An *en-suite r*oom is preferable, but if one is not available, a commode should be dedicated for each patient's individual use
- Where placement in a single room or cohorting is not achievable, consider the patient population when determining patient placement. Consult Infection Control professionals for advice before placement
- The door to the patient's room should be kept closed to minimise spread to adjacent areas unless it is likely to compromise patient care
- The appropriate signage should be placed on the outside of the door indicating Contact Precautions
- Where possible and without compromising patient care, routine care of patients colonised or infected with MDRO should be carried out after attending to other patients. Healthcare institutions should have a policy on the use of shared facilities or equipment

B. ***Hand hygiene and personal protective equipment (PPE)***

- Hand hygiene should be performed using an antimicrobial or alcohol hand rub agent before and after touching a patient

- Gloves are required as outlined for Standard Precautions, where there is potential contact with blood or body fluids. In addition, as part of Contact Precautions, they should be donned prior to entering an isolation room or cohort space for all interactions that may involve contact with the patient or potentially contaminated areas in the patient's environment
- Gloves should be removed on completion of a task and before leaving the patient's single room or cubicle
- Hand hygiene should be performed immediately upon removal of gloves with an antimicrobial or alcohol-based handrub
- A non-sterile disposable apron or gown may be required for very close and more extensive contact (e.g. bathing, diaper change, turning patient etc.); advice on this should be obtained from the Infection Prevention and Control (IPC) Team. The apron or gown should be removed and discarded after use
- Masks may occasionally be necessary for healthcare workers such as when performing splash or aerosol-generating procedures

C. ***Visitors***

- Visitors to the cubicle or ward and staff from other wards and departments (e.g. physiotherapists, radiographers, other medical teams, students etc.) should only enter after permission and instruction from the nurse-in-charge. A signage detailing isolation precautions should be displayed prominently

D. ***Care givers training***

- Hand hygiene and appropriate precautions for handling body fluids should be incorporated in caregiver training. Caregivers of patients colonised by MDROs should be instructed on relevant elements of Contact Precautions

E. ***Cleaning and decontamination of environment and patient-care equipment***

- Local policies for environmental cleaning and equipment decontamination, waste and linen management should state the necessary standards, and should be applied rigorously
- Wards should be cleaned regularly as part of a general programme of environmental hygiene
- Adequate hand hygiene facilities and alcohol-based handrub should be available for staff and visitor hand decontamination before and after contact with the patient or their immediate environment
- Instruments or equipment should preferably be single-patient use
- Multiple-patient-use items should be decontaminated appropriately before use on another patient in accordance with local policy or manufacturer's instructions
- All patient care equipment or supplies must be effectively cleaned and disinfected before use on another patient
- The room in which a patient with an MDRO has been cared for should be cleaned after the patient's discharge with a chlorine releasing agent, such as hypochlorite, with special attention to frequent-touch areas, horizontal surfaces and dust-collecting areas (e.g. ventilation grids). For equipment that could not withstand chlorine, alternatives may be considered with guidance from IPC team. Curtains should be removed and laundered if not single-use disposable curtains. Pillows and mattress covers should be checked for damage
- After an outbreak or incident of MDRO colonisation or infection, isolation rooms (or the whole of a ward after more extensive outbreaks) must be cleaned with appropriate disinfectant thoroughly to reduce environmental contamination.
- Documents including the nursing notes and patient's chart should not be taken into the room
- Only essential equipment and supplies should be taken into the patient's room. Stockpiling of supplies should be avoided

F. Antiseptic body wash or wipes

- Antiseptic e.g. 4% chlorhexidine, liquid chlorhexidine (2%) or 2% chlorhexidine-impregnated wipes, octenidine or equivalent products; are used to bathe patients daily in acute care setting. Chlorhexidine, if used, is usually not used above the jaw line or on open wounds
- In long-term care settings this type of an intervention might be used on targeted high-risk residents (e.g., residents that are totally dependent upon healthcare personnel for activities of daily living, are ventilator dependent, are incontinent of stool, or have wounds whose drainage is difficult to control) or high-risk settings (e.g., ventilator unit)

G. ***Linen***

- All linen from patients infected with or colonised with MDRO should be considered to be contaminated or infected including bedding and adjacent curtains. Linen should be removed from the bed with minimal agitation and should be further managed in accordance with local policy and national guidance, where provided

H. ***Re-usable bedpans and urinals***

- Dedicated bedpans or urinals are not required, provided that the bedpan washer or disinfector is in working order

I. ***Crockery and cutlery***

- No special precautions are necessary with these items

J. ***Patient movement and transport***

- When a patient with an MDRO is transferred to another healthcare facility, the clinical team is responsible for the patient and should inform the receiving clinical and infection control staff of the patient's MDRO Clinical Record Information
- During actual transportation between departments, it is important to maintain patient confidentiality

- As the patient is not normally in direct contact with surrounding environmental surfaces or the staff members clothing during transportation, aprons or gloves are not required unless directed by Standard Precautions

K. ***Ambulance transportation***

- Ambulance staff should adhere to Standard Precautions with all patients
- To minimise the risk of cross infection with any infectious agent, ambulance staff should use an alcohol based hand gel or rub after contact with all patients as part of standard precautions
- If ambulance transfer is required, the ambulance service should be notified in advance of any infection risk by the responsible ward staff
- The patient may travel with other patients unless notified to the contrary; transport should not be shared if the patient is deemed at high risk of transmission of MDRO, e.g. if they have diarrhoea, discharging lesions which cannot be covered with an impermeable dressing, or if the other patients requiring transport are especially vulnerable e.g. immunocompromised or if recommended by the IPC team
- Unnecessary equipment and linen should be removed before transporting patient
- Patients on stretchers should be wrapped in a clean sheet before leaving the ward
- Blankets and sheets should be placed into a separate laundry bag after transport of patient
- Local areas of patient contact e.g. chair and stretcher should be cleaned and disinfected as per local decontamination policy
- After patient contact, protective clothing and gloves should be removed and hands decontaminated using an alcohol-based handrub if visibly clean hands or antiseptic handwash, if necessary
- Fumigation and prolonged airing of the ambulance is not necessary

L. ***Deceased patients***

- The Infection Control precautions for handling deceased patients are the same as those used in life. Any lesions should be covered with impermeable dressings. Plastic body bags are not necessary, but may be employed as part of general practice in accordance with standard precautions for all patients

Adapted from "Guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities" *J Hosp Infect* 2006; 63S: S1-S44

Appendix 3 Laboratory Diagnosis of MRSA, VISA and VRSA

Staphylococcus aureus colonises 30% of healthy humans but may cause severe infections as well. Methicillin–resistant *S. aureus* (MRSA) is an important cause of healthcare-associated infections.

Vancomycin non-susceptible *S. aureus* has emerged likely as a result of increasing vancomycin use to treat MRSA. For serious MRSA infections e.g. bacteraemia, vancomycin susceptibility testing should be done via minimum inhibitory concentration (MIC) method. Vancomycin–intermediate *S. aureus* (VISA) i.e. *S. aureus* strains (MRSA) with vancomycin MIC≥2 g/L has been associated with treatment failure. VanA-mediated vancomycin-resistant *S. aureus* (VRSA, vancomycin MIC>16 mg/L) is rare but it is important to look out for it. Suspected VRSA strains should be sent to National Public Health Laboratory (NPHL).

Appendix 4 Laboratory Diagnosis of VRE

VRE refers to vancomycin-resistant *Enterococcus faecium* or vancomycin-resistant *Enterococcus faecalis.*

The first isolate of glycopeptides (vancomycin or teicoplanin)-resistant *enterococcus* (GRE) in a patient should be identified to species level and antimicrobial susceptibility to vancomycin and teicoplanin performed to ascertain the phenotype (Van A or van B mediated resistance). Alternatively, PCR for vanA or vanB genes may be used. Molecular typing by PCR may be considered if an outbreak is being investigated. Selective agars and molecular assays are available to screen for rectal carriage of GRE.

Appendix 5 Laboratory Diagnosis of CP-CRE

The presence of a carbapenemase-producing carbapenem resistant *Enterobacteriaceae* (CP-CRE) is first suspected when resistance to a carbapenem is detected by antimicrobial susceptibility testing. (MICs of ≥0.5 for ertapenem and ≥1 mg/L for imipenem and meropenem). The most sensitive carbapenem for detecting CP-CRE is ertapenem, however it is also the least specific because ertapenem resistance may also occur as a result of Extended-Spectrum Beta-Lactamase **(**ESBL) or AmpC production in combination with porin loss.

The presence of a carbapenemase may be detected using a modified Hodge test. There may be false positive results due to CTX-M ESBLs and AmpC production. Also New Delhi metallo-beta-lactamase-1 (NDM-1) carbapenemase production is associated with a weak modified Hodge test result. Combined use of the modified Hodge test and the ROSCO KPC, MBL and OXA-48 kit allows presumptive identification of the type of carbapenemase.

Confirmation of the type of carbapenemase is done by polymerase chain reaction (PCR) amplification and sequencing of the carbapenemase gene. This is available at the National Public Health Laboratory (NPHL).

A number of selective media are available for screening CP-CRE from stool specimens. This is a rapidly developing field and the latest literature should be consulted.

Rapid tests have been developed which directly detect carbapenem hydrolysis e.g. (CarbaNP) (Nordmann et al 2012) and MALDI-TOF and are presently being investigated

References

1. Galani I, Rekatsina PD, Hatzaki D, Plachouras D, Souli M, Giamarellou H. Evaluation of different laboratory tests for the detection of metallo-β-lactamase production in *Enterobacteriaceae*. *J Antimicrob Chemother* 2008; 61:548- 53.
2. Tsakris A, Kristo I, Poulou A, Themeli-Digalaki K, Ikonomidis A, Petropoulou D *et al*. Evaluation of boronic acid disk tests for differentiating KPC-possessing *Klebsiella pneumoniae* isolates in the clinical laboratory. *J Clin Microbiol* 2009; 47:362-7.
3. Pasteran F, Mendez T, Guerriero L, Rapoport M, Corso A. Sensitive screening tests for suspected class A carbapenemase production in species of *Enterobacteriaceae*. *J Clin Microbiol* 2009; 47:1631-9.
4. Miriagou V, Pappagianistis CC, Tzelepi E, Bou Casals J, Legakis NJ, Tzouvelekis L S. Detection of VIM-1production in *Proteus mirabilis* by an imipenem dipicolinic acid double disk synergy test. *J Clin Microbiol* 2010; 4: 667–668.
5. Seah C, Low DE, Patel SM, Melano RGl. Comparative evaluation of a chromogenic agar medium, the modified Hodge test, and a battery of meropenem- inhibitor discs for detection of carbapenemase activity in *Enterobacteriacae*. *J Clin Microbiol* 2011; 49: 1965–1969.
6. Samra Z, Bahar J, Madar-Shapiro L, Aziz N, Israel S, Bishara J. Evaluation of CHROMagar KPC for rapid detection of carbapenem-resistant *Enterobacteriaceae*. *J Clin Microbiol* 2008; 46: 3110-3111.
7. Nordmann P, Girlich D, Poirel L. Detection of carbapenemase producers in *Enterobacteriaceae* using a novel screening medium. *J Clin Microbiol* 2012; 50: 2761-6.
8. Spanu T, Fiori B, D'Inzeo T, Canu G, Campoli S, Giani T *et al*. Evaluation of the New NucliSENS EasyQ KPC test for rapid detection of *Klebsiella pneumoniae* carbapenemase genes (blaKPC). *J Clin Microbiol* 2012; 50:2783-5.
9. Kaase M, Szabados F, Wassill L, Gatermann SG. Detection of carbapenemases in *Enterobacteriaceae* by a commercial multiplex PCR. *J Clin Microbiol* 2012; 50:3115-8.

10. Endimiani A, Hujer AM, Hujer KM, Gatta JA, Schriver AC, Jacobs MR *et al*. Evaluation of a commercial microarray system for detection of SHV-, TEM-, CTX-M-, and KPC-type beta-lactamase genes in Gram-negative isolates. *J Clin Microbiol* 2010; 48:2618-22.
11. Bogaerts P, Hujer AM, Naas T, de Castro RR, Endimiani A, Nordmann P *et al*. Multicenter evaluation of a new DNA microarray for rapid detection of clinically relevant *bla* genes from beta-lactam-resistant gram-negative bacteria. *Antimicrob Agents Chemother* 2011; 55:4457-60.
12. Cuzon G, Naas T, Bogaerts P, Glupczynski Y, Nordmann P. Evaluation of a DNA microarray for the rapid detection of extended-spectrum β-lactamases (TEM, SHV and CTX-M), plasmid-mediated cephalosporinases (CMY-2-like, DHA, FOX, ACC-1, ACT/MIR and CMY-1-like/MOX) and carbapenemases (KPC, OXA-48, VIM, IMP and NDM). *J Antimicrob Chemother* 2012; 67:1865-9.

Appendix 6 *Clostridium difficile*

Clostridium difficile infection (CDI) is the most common cause of diarrhoea-associated with antimicrobial therapy. Clinical disease ranges from toxin-mediated symptoms associated with mild diarrhea, which can resolve without treatment, to severe cases such as pseudomembranous colitis, toxic megacolon and peritonitis that can lead to death. In mild disease, diarrhoea is usually the only symptom; where diarrhea is defined as the passage of 3 or more loose or liquid stools per day, or as more frequently than is normal for the individual (WHO). A single case of severe CDI or a single death due to CDI should always prompt further investigations.

Symptomatic CDI patients shed hardy spores of *C. difficile* via their stools into the environment. The spread of hardy spores of *C. difficile* via contact plays an important role in the transmission of CDI in healthcare facilities. Isolation of symptomatic CDI patients is a key step in preventing the transmission of *C. difficile* within healthcare facilities.

Infection Control measures in management of symptomatic CDI patients

1. **Patient placement**

   Symptomatic patients with CDI should preferably be nursed in a single-bedded room with hand washing facilities, en-suite toilet, dedicated care equipment and the door kept closed. Personal protective equipment should be put on before entering the isolation room (or area) with symptomatic CDI patient(s). If isolation in single rooms is not possible, isolation in cohorts should be undertaken. Cohorted patients should be managed by designated staff, where possible, to minimize the risk of infection to other patients (or staff). Isolation precautions may be discontinued when the patient has been symptom-free for 48 hours and bowel movements have returned to normal. If the patient has recurrent CDI, consideration may be given to leaving the patient in a single room accommodation even after resolution of symptoms to minimize the risk of transmission.

2. Hand hygiene

The spread of *C. difficile* spores via direct and indirect contact is the major route of transmission of CDI in healthcare facilities. Meticulous hand hygiene with soap and water or antiseptics is recommended for all staff if hands are visibly soiled where the physical removal of spores is achieved with rinsing.

3. Equipment and environment

Care equipment (such as commodes, blood pressure cuffs and stethoscopes) should be dedicated to a single patient. All care equipment should be carefully cleaned and disinfected using a sporocidal agent (e.g. 1000 ppm hypochlorite) immediately after use on a CDI patient. Rectal thermometers should not be shared, and use of electronic thermometers with disposable sheaths should be avoided. Single-use items (including thermometers and other care equipment) should be used when possible.

For environmental cleaning, healthcare facilities should refer to the MOH Environmental Cleaning Guidelines for Healthcare Settings (June 2013).

Infection Control measures in management of residents with *C difficile* at ILTCs

Asymptomatic patients with *C difficile* should be not declined admission to an ILTC. Standard Precautions are to be applied during their management.

Early diagnosis is essential for preventing and controlling CDI in the community. The possibility of developing CDI should be considered when persons with diarrhoea also have one or more of the following risk factors:

- Current or recent (within at least the past 12 weeks) use of antimicrobials
- Increased age
- Prolonged current or recent hospital stay

- Serious underlying diseases or poor physical health
- Surgical procedures
- Immunocompromising conditions
- Use of proton pump inhibitors (gastric acid reducing agents)

When residents in the ILTCs have severe diarrhoea (and fever or other symptoms) and any of the risk factors listed above, admission to hospital should be considered as early as possible.

Staff in ILTCs should wear disposable gloves and disposable aprons for all contact with persons with diarrhea. After contact staff should dispose of the gloves and aprons, and practice hand hygiene (soap and water or alcohol-based hand rub agent). If possible, persons with diarrhoea and/or confirmed CDI should be nursed in single rooms; otherwise they may be cohorted. Precautions may be discontinued *whe*n patients have been symptom-free for at least 48 hours and bowel movements have returned to normal. Precautions may need to be continued in patients with recurrent CDI.

References:

1. Cohen SH, Gerding DN, Johnson S *et al*. Clinical Practice Guidelines for *Clostridium difficile* Infection in Adults: 2010 Update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA). Infect Control Hosp Epidemiol 2010; 31(5): 431-455.
2. Control of *Clostridium difficile* Infection (CDI) Outbreaks in Hospitals. Public Health Division: Public Health Protection and Prevention Branch Ministry of Health and Long-Term Care December 2009, Ontario, Canada.
3. Guidance on Prevention and Control of Clostridium difficile Infection (CDI) in Healthcare Settings in Scotland. Health Protection Network Scottish Guidance September 2009.
4. APIC Implementation Guide to Preventing *Clostridium difficile* Infections, February 2013.

Appendix 7: Data Collection and Reporting Requirements for MDROs

National Data Collection and Reporting Requirements for MRSA

MRSA FORM 1

NATIONAL DATA COLLECTION / REPORTING REQUIREMENTS FOR MRSA CASES (INPATIENTS ONLY)

Background & Instructions
(i) National data collection / reporting requirements for MRSA cases are to support the implementation of MOH's MDRO Guidelines
(ii) One (1) form is required: MRSA FORM 1
(iii) MRSA FORM 1 details data requirements surrounding the number of MRSA bacteraemia cases (i.e. blood culture positive) in hospitals.
(iv) Data shall be submitted manually by the hospital using the excel template provided by MOH
(v) MRSA FORM 1 must reach MOH within two (2) weeks after every completed quarter, e.g. submission of January to March data by 15th April

NAME OF HOSPITAL:

REPORTING YEAR:

Definition (inclusion criteria*)	**(a) within (</=) 48hours of admission, who HAVE been an inpatient in your own institution within preceding 7 days.**			**(b) after (>)48 hours of admission**			**(c) Other patients with blood culture positive for MRSA:**		
Additional Information							**within (</=) 48 hours of admission, who HAVE NOT been an inpatient in your own institution within preceding 7 days.**		
	Jan	**Feb**	**Mar**	**Jan**	**Feb**	**Mar**	**Jan**	**Feb**	**Mar**
No. of patients (n)									
No. of Patient Days (N)									
No. of Discharges and Deaths (N)									
	Apr	**May**	**Jun**	**Apr**	**May**	**Jun**	**Apr**	**May**	**Jun**
No. of patients (n)									
No. of Patient Days (N)									
No. of Discharges and Deaths (N)									
	Jul	**Aug**	**Sep**	**Jul**	**Aug**	**Sep**	**Jul**	**Aug**	**Sep**
No. of patients (n)									
No. of Patient Days (N)									
No. of Discharges and Deaths (N)									
	Oct	**Nov**	**Dec**	**Oct**	**Nov**	**Dec**	**Oct**	**Nov**	**Dec**
No. of patients (n)									
No. of Patient Days (N)									
No. of Discharges and Deaths (N)									
	Jan to Dec 2013			**Jan to Dec 2013**			**Jan to Dec 2013**		
No. of patients (n)	**0**			**0**			**0**		
No. of Patient Days (N)	**0**			**0**			**0**		
No. of Discharges and Deaths (N)	**0**			**0**			**0**		

Numerator (n) :	Total number of MRSA Bacteraemia (a+b+c)	Rate		(n)/(N) x 10,000
Denominator (N) :	Total number of patient days			
Numerator (n) :	Total number of MRSA Bacteraemia (a+b+c)	Rate		(n)/(N) x 10,000
Denominator (N) :	Total number of discharges (including deaths)			
Numerator (n) :	Total number of hospital acquired MRSA Bacteraemia (a+b)	Rate		(n)/(N) x 10,000
Denominator (N) :	Total number of patient days			
Numerator (n) :	Total number of hospital acquired MRSA Bacteraemia (a+b)	Rate		(n)/(N) x 10,000
Denominator (N) :	Total number of discharges (including deaths)			

Legend:

1) Exclusion criterion: Any multiple positive MRSA blood cultures within 14 days will be counted as one event. 14 days exclusion criterion to be confirmed

National Data Collection and Reporting Requirements for VRE

VRE FORM 1

NATIONAL DATA COLLECTION / REPORTING REQUIREMENTS FOR VRE CASES (INPATIENTS ONLY)

Background & Instructions

(i) National data collection / reporting requirements for VRE cases are to support the implementation of MOH's MDRO Guidelines
(ii) One (1) form is required: VRE FORM 1
(iii) VRE FORM 1 details data requirements surrounding the number of VRE cases in hospitals.
(iv) Data shall be submitted manually by the hospital using the excel template provided by MOH
(v) VRE FORM 1 must reach MOH within two (2) weeks after every completed month, e.g. submission of January data by 15th February

NAME OF HOSPITAL:

REPORTING YEAR:

Month	(a) No of VRE Clinical Cases	(b) No of VRE Cases from Surveillance (Based on Risk Factors)	(c) No of VRE Cases from Contact Tracing[1]	Total No of VRE Cases (a+b+c)	(d) Total No of Surveillance Patients Screened i.e. Denominator for (b)	(e) Total No of Contacts Traced i.e. Denominator for (c)	Indicate if any clusters identified[2] (Yes/No)	If yes, indicate size of cluster/s (No of cases involved)	*Remarks (e.g. Cluster info)
JAN				0					
FEB				0					
MAR				0					
APR				0					
MAY				0					
JUN				0					
JUL				0					
AUG				0					
SEP				0					
OCT				0					
NOV				0					
DEC				0					
Total	0	0	0	0	0	0			

Legend:

(1) Number of cases detected from contact tracing of BOTH clinical cases and surveillance cases. If contact tracing identifies VRE case(s) that is/are not related to the index VRE case, the identified VRE case(s) should be counted as a "Surveillance" case i.e. add to the numbers in "(b) No ofVRE Cases from

(2) Definition of Cluster: More than 2 standard deviations from the mean, may or may not be epidemiologically related

National Data Collection and Reporting Requirements for CP-CRE

CP-CRE FORM 1

NATIONAL DATA COLLECTION / REPORTING REQUIREMENTS FOR CP-CRE CASES (INPATIENTS ONLY)

Background & Instructions

(i) National data collection / reporting requirements for CP-CRE cases are to support the implementation of MOH's MDRO Guidelines
(ii) Two (2) forms are required: CP-CRE FORM 1 and CP-CRE FORM 2.
(iii) **CP-CRE FORM 1 details data requirements surrounding the number of CP-CRE cases in hospitals.** CP-CRE FORM 2 details data requirements surrounding individual CP-CRE cases in hospitals.
(iv) Data shall be submitted manually by the hospital using the excel template provided by MOH
(v) CP-CRE FORM 1 must reach MOH within two (2) weeks after every completed month, e.g. submission of January data by 15th February
(vi) Submission of CP-CRE FORM 1 is required for both new and old CP-CRE cases.

NAME OF HOSPITAL:

REPORTING MONTH AND YEAR:

Month		(a) No of CP-CRE Clinical Cases				(b) No of CP-CRE Cases from Surveillance (Based on Risk Factors)				(c) No of CP-CRE Cases from Contact Tracing[1]				Total No of CP-CRE Cases (a+b+c)	(d) Total No of Surveillance Patients Screened i.e. Denominator for (b)	(e) Total No of Contacts Traced i.e. Denominator for (c)	Indicate if any clusters identified (Yes/No)	If yes, indicate size of cluster/s (No of cases involved)	*Remarks (e.g. Name of 'Other' CP-CRE reported, Cluster info)
		No of NDM	No of KPCs	Other carbapenemases[4]		No of NDM	No of KPCs	Other carbapenemases		No of NDM	No of KPCs	Other carbapenemases							
				OXA	Others*			OXA	Others*			OXA	Others*						
January	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
February	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
March	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
April	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
May	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
June	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
July	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
August	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
September	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
October	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
November	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
December	New Cases[2]													0					
	Old Cases[3]													0					
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					
Total	New Cases[2]	0	0	0	0	0	0	0	0	0	0	0	0	0					
	Old Cases[3]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0					

Legend:

(1) Number of cases detected from contact tracing of **BOTH** clinical cases and surveillance cases. If contact tracing identifies CP-CRE case(s) that is/are not related to the index CP-CRE case e.g. the CP-CRE case is of a different type from the index case, the identified CP-CRE case(s) should be counted as a "Surveillance" case i.e. add to the numbers in "(b) No of CP-CRE Cases from Surveillance".
(2) New cases refer to i) patients who are tested positive for CP-CRE for the first time, and ii) previously CP-CRE positive patients who are now tested positive for a different CP-CRE organism (e.g. previously NDM1 but now tested positive for KPC)

(3) Old cases refer to patients who are tested positive for the same CP-CRE organism in a different admission episode

(4) CP-CRE FORM 2 must also be submitted for CP-CRE cases that are "Other carbapenemases"

(5) Definition of Cluster: More than 2 standard deviations from the mean, may or may not be epidemiologically related

CP-CRE FORM 2

NATIONAL DATA COLLECTION / REPORTING REQUIREMENTS FOR CP-CRE CASES (INPATIENTS ONLY)

Background & Instructions

(i) National data collection / reporting requirements for CP-CRE cases are to support the implementation of MOH's MDRO Guidelines
(ii) Two (2) forms are required: CP-CRE FORM 1 and CP-CRE FORM 2.
(iii) CP-CRE FORM 1 details data requirements surrounding the number of CP-CRE cases in hospitals. **CP-CRE FORM 2 details data requirements surrounding individual CP-CRE cases in hospitals.**
(iv) Data shall be submitted manually by the hospital using the excel template provided by MOH
(v) CP-CRE FORM 2 must reach MOH within two (2) weeks after every completed quarter, e.g. submission of January to March data by 15th April
(vi) Submission of CP-CRE FORM 2 is required only for NEW CP-CRE cases only.
(vii) For questions with square ☐ checkboxes, you may check more than one box.

Patient's code (Hospital assigned individual patient ID) :	
Age	
Sex	○ Female ○ Male
Ethnic group	○ Chinese ○ Malay ○ Indian ○ Eurasian ○ Others
Nationality	○ Singaporean ○ Others, please specify:
Ward class	○ A ○ B1 ○ B2/B2+ ○ C
Bed Configuration at time of culture taken	○ Single/Isolation room ○ 2-bedded room ○ 4-bedded room ○ 6-bedded room ○ 8-bedded room ○ 10-bedded room ○ Others, please specify:
Date of Admission (dd/mm/yyyy)	
Date of Culture (dd/mm/yyyy)	
Site	☐ Rectal swab/Stool ☐ Urine ☐ Wound/Tissue ☐ Bile ☐ Blood ☐ Others, please specify:
Organism	☐ E. coli ☐ Kleb sp ☐ Proteus ☐ Enterobacter ☐ Kleb pneu ☐ Others, please specify:
CP-CRE results	☐ NDM ☐ KPC ☐ OXA, please specify number: ☐ VIM ☐ IMP ☐ Others, please specify:
Antimicrobial susceptibility based on the first CP-CRE organism identified (S/I/R)	1.Imipenem: 2. Meropenem: 3. Ertapenem: Others:
Date of Discharge / Death (dd/mm/yyyy) and Mode of Discharge	Date of Discharge/Death: Discharge Mode: **If death, please specify cause of death:* *If others, please specify mode of discharge:*
Patient risk factors:	
Admission into any healthcare facility in last 30 days	○ Yes, please specify: ○ No ○ Unknown
Countries travelled to/lived in within the 1 year, excluding transit	○ Yes, country & approximate dates: ○ No ○ Unknown
Any hospitalisation overseas within past 1 year	○ Yes, country & approximate dates: ○ No ○ Unknown
ADL on arrival	○ Ambulant ○ Minimal assistance required ○ Wheelchair bound ○ Bed bound

Admission diagnosis	
History of Admission to ICU before CP-CRE is identified (If multiple episodes, enter the latest admission)	○ Yes, please indicate date of admisssion and discharge from ICU: ○ No Admission _____ Discharge _____
History of Admission to HD/ICA before CP-CRE is identified (If multiple episodes, enter the latest admission)	○ Yes, please indicate date of admission and discharge from HD/ICA : ○ No Admission _____ Discharge _____
Comorbidity condition(s) (See table below for definition)	☐ Chronic Lung Disease ☐ Cardiovascular Disease ☐ Diabetes Mellitus ☐ End Stage Renal Disease (dialysis) ☐ Haematology ☐ Immunodeficiency ☐ Liver disease ☐ Malignancy ☐ Neurological disease ☐ Renal disease ☐ Skin wound ☐ Transplantation ☐ Others, please specify: _____ ☐ Nil
Any invasive procedures within this admission episode prior to identification of CP-CREs:	☐ Angiogram ☐ Bronchoscopy ☐ Chest tube insertion ☐ Colonoscopy ☐ Gastroscopy ☐ Others, please specify: _____ ☐ Nil
Any surgery within this admission episode prior to identification of CP-CREs:	☐ Cardio/thoracic ☐ Colorectal ☐ Ear, Nose and Throat ☐ General Surgery ☐ Gynecology ☐ Head & neck ☐ Neuro-surgery ☐ Non-spinal Orthopedic ☐ Plastic Surgery ☐ Spinal ☐ Transplantation ☐ Urology ☐ Others, please specify: _____ ☐ Nil
Other Multi-Drug Resistant Organisms (MDROs) within past 1 year (As per AMR WG definition)	☐ Imipenem-resistant Acinetobacter baumannii ☐ Imipenem-resistant Pseudomonas aeruginosa ☐ ESBL-producing organisms ☐ MRSA ☐ VRE ☐ Others, please specify: _____ ☐ Nil
Device presence within 1 month prior to CP-CRE	☐ Central line ☐ Drains or Chest Tube ☐ Endo Tracheal Tube ☐ Enteral feeding ☐ Intra-arterial line ☐ Tracheostomy tube ☐ Urine catheter ☐ Others, please specify: _____ ☐ Nil
Exposure to antibiotics in last 30 days prior to identification of CP-CREs (See list below for antibiotics classification)	☐ Penicillins ☐ β-lactam/β-lactamase inhibitor combinations ☐ Cephalosporins ☐ Carbapenems ☐ Fluoroquinolones ☐ Glycopeptide ☐ Metronidazole ☐ Aminoglycosides ☐ Macrolide ☐ Colistin/PB ☐ Tetracycline ☐ Others, please specify: _____ ☐ Nil
Exposure to any dose of immunosuppresive drug (excluding topical agents) in last 30 days prior to identification of CP-CREs	☐ Steroid ☐ Chemotherapy drugs ☐ None ☐ Others, please specify: _____
Radiation Therapy (eg Deep X-ray Therapy) in last 30 days prior to identification of CP-CREs	○ Yes ○ No

Appendix 8: Credits for MDRO Guidelines Development

We acknowledge the valuable contributions of the following experts who have contributed to the development of this MDRO Guidelines:

Name	**Designation and Institution**
Dr Ling Moi Lin	Director, Infection Control, Singapore General Hospital Vice Chair, Infection Control Workgroup of the National Antimicrobial Taskforce
Dr Brenda Ang	Senior Consultant, Department of Infectious Diseases, Tan Tock Seng Hospital Chair, Infection Control Workgroup of the National Antimicrobial Taskforce
A/P Dale Fisher	Head, Division of Infectious Diseases, National University Hospital
Ms Ng Kim Sim	Senior Nurse Manager, Infection Control, Alexandra Hospital
Ms Soong Sau Leng	Nurse Clinician, Infection Control, Alexandra Hospital
Ms Lim Siok Hong	Assistant Director, Infection Control, KK Women's and Children's Hospital
Dr Colin Ngeow	Consultant, Medical Services Division, St Luke's Hospital
Dr Nancy Tee	Head and Senior Consultant, Department of Pathology and Laboratory Medicine, KK Women's and Children's Hospital Chair, Antimicrobial Resistance Workgroup of the National Antimicrobial Taskforce
Dr Koh Tse Hsien	Senior Consultant, Department of Pathology, Singapore General Hospital
Ms Chua Chor Guek	Senior Nurse Manager, Infection Control, National Kidney Foundation
Ms Lee Shu Lay	Infection Control Manager, Nursing Administration, Thomson Medical Centre
Ms Chua Gek Hong	Chief Infection Control Officer, Infection Control, Parkway Hospitals
Ms Gillian Beins	Senior Nurse Manager, St Joseph's Home and Hospice
Ms Than Aye @ San Yi	Nurse Manager, United Medicare (Elizabeth Dr) Pte Ltd
Dr Ng Yeuk Fan	Associate Consultant, Standards and Quality Improvement Division, Ministry of Health Singapore
Ms Helen Goh	Manager (Patient Safety), Standards and Quality Improvement Division, Ministry of Health Singapore
Ms Winnie Tan	Assistant Manager (Patient Safety), Standards and Quality Improvement

	Division, Ministry of Health Singapore

Last but not least, the Ministry of Health would like to thank members of the National Antimicrobial Taskforce, members of the National Public Health Laboratory, as well as all other experts who have contributed valuable time to the development of these guidelines.