A Guide to the NOHARM System

Ministry of Health and Wellness
MAURITIUS

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Approval Form

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A GUIDE TO THE NATIONAL ONE HEALTH ANTIMICROBIAL RESISTANCE MONITORING SYSTEM			
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PEER REVIEW

A pilot version was reviewed by Dr. A. Ammon (Director of European Center for Disease Prevention and Control) and by Dr. M. Issack (Microbiologist) in 2021 and the National IPC Committee approved that version in 2021.

Date of next review: January 2025

A Guide to the National One Health Antimicrobial Resistance Monitoring System

Introduction

Ad hoc surveillance of antimicrobial resistance (AMR) patterns amongst bacterial species has been carried out by the Central Health Laboratory (CHL) since the early 2000s in Mauritius. The country joined the World Health Organization's Global Antimicrobial Resistance Surveillance System (GLASS) in 2018 with the first report being submitted to the national authorities in March 2023.[1]

Given the worrying rise in AMR among specific organisms in Mauritius, it was proposed in 2021 that outbreaks of multi-drug resistant organisms (MDRO) should be notified to clinicians in a more systematic and regular manner so as to promote antimicrobial stewardship and to improve Infection Prevention and Control (IPC) practices, whereby a pilot project was started to gather culture data every month from patients admitted in the intensive care units (ICU) of the public hospitals.

During this pilot project, case definitions for outbreaks and high-priority MDRO (HPMDRO) were developed and approved by the Ministry of Health and Wellness (MOHW) – in 2022, 34 outbreaks of HPMDRO were notified, all of which were investigated by the regional IPC teams and some of which were investigated by a national team.[2]

So far, no significant improvement in the rate of AMR among HPMDRO has been noted. Hence, an expanded national surveillance strategy is being proposed so as to increase its impact. Considering the well-recognized importance of the One Health concept in successfully tackling the AMR scourge, it was deemed appropriate to name this strategy the "National One Health Antimicrobial Resistance Monitoring" (NOHARM) system.

This document updates the case definitions that were used in 2021 and provides a guide to all stakeholders who are involved with NOHARM.

Objectives

1. Estimate the prevalence of some designated HPMDRO in certain predefined locations – this can include the animal and environmental sectors.
2. Estimate the incidence of some designated HPMDRO in certain predefined locations which may also include key areas of importance to the animal and environmental sectors.
3. Recognize when outbreaks occur and inform relevant stakeholders in a timely manner so that actions can be taken.
4. Liaise with the IPC teams (and antimicrobial / diagnostic stewardship teams, if any) to help with outbreak investigations and to promote best practices.
5. Provide basic epidemiological support on HPMDRO to healthcare facilities.
6. Inform national authorities about the trends in HPMDRO in the country so as to help with policy decisions.
7. Notify clinicians and middle management about the rate of HPMDRO in their healthcare facilities so that awareness can be raised and so that treatment guidelines are properly aligned with local needs.

Weaknesses of the current system

1. Outbreaks of HPMDRO often occur in locations other than ICUs but these are not being identified; therefore, appropriate actions are not necessarily being taken to stop the spread of HPMDRO.
2. Since susceptibility testing for fungi is not carried out by CHL, it is not possible to correctly identify multi-drug resistant fungal infections.
3. Surveillance in the veterinary and environmental sectors are not being conducted.
4. No functional national coordinating center exists, and no proper clinical and surveillance teams are in place to help with monitoring.
5. Currently, no link exists with the drug and pharmaceutic committee and with any diagnostic or antimicrobial stewardship teams.
6. Dissemination of data on the prevalence of AMR among hospitals is limited, mostly because of the use of a manual system (through letters) instead of an electronic system (especially since emails are often left unread).
7. Data analysis is not being carried out by age or gender at the moment.
8. Outbreak notifications are often made 4 to 6 weeks after an outbreak has started which is too late by international standard – usually, notification should occur within 7 days or less.
9. The private sector is not covered by the surveillance system due to difficulties to access data in the private clinics.
10. Given its time-consuming and resource-intensive aspects, case-based surveillance is not done – this means that hospital-acquired infections are not identified. Culturing MDROs more than 2 calendar days after admission in a patient may not be accurate enough to define a hospital-acquired infection.
11. Without a proper Laboratory Information Management System (LIMS), data entry remains laborious and inaccurate:
    a. Some duplicates are not removed because unique patient identifiers are not in use.
    b. Laboratory request forms can be difficult to decipher due to poor handwriting.
    c. Incorrect entries or missing entries are often noted on request forms.
    d. The same hospital location can be identified by different abbreviations which makes data analysis difficult.
    e. The ages of patients are often wrong in their medical folders.
12. Gathering clinical details like patient outcomes (e.g., mortality rate) and patterns of antibiotic usage takes time and cannot be done without additional staff.
13. Suitably detailed outbreak investigations are rarely carried out.
14. Data about transfers of patients are not available i.e., some HPMDRO may be acquired elsewhere but this would not be reflected in the database.

Roadmap

1. 2021-2022 (phase 1): Pilot project to start HPMDRO surveillance in ICUs.
2. 2023-2024 (phase 2): Expand HPMDRO surveillance to non-ICU settings.
3. 2025-2026 (phase 3): Merge NOHARM indicators with those from GLASS and include non-human health surveillance sites.
4. 2027-2028 (phase 4): Upscale surveillance to the private sector.

Phase 2 will be started provided sufficient support is available for data collection.

Structure

A national AMR surveillance system comprises of three core components: a national coordinating centre (NCC), a national reference laboratory (NRL) and AMR surveillance sites.

The role of the NCC includes:

- To facilitate linkages across human health, animal health and environmental health.
- To develop national surveillance standards and protocols.
- To provide guidance on data collection and reporting.

Currently, an NCC has not been set up and the National IPC Focal Point is coordinating NOHARM. Prior to embarking into phase 2, it is imperative that additional human resource be identified for data collection, validation, cleaning, integration, analysis, aggregation, compilation and reporting – an epidemiologist, a data entry officer and / or a health surveillance officer should be recruited to be responsible for the data flow even though this part of the work can be simplified with the implementation of LIMS.

The NRL is the CHL which is located at Victoria Hospital, Candos. The bacteriology department of the CHL participates yearly in a proficiency testing (External Quality Assurance) organized by the South African National Institute of Communicable Diseases on behalf of WHO AFRO and its performance for identification and antibiotic susceptibility testing has been excellent. A standard form containing patient data accompanies every sample sent for susceptibility testing to the CHL.

Details about the AMR sites are provided in the next section.

Surveillance methods

Cases will be found among clinical samples sent to the CHL, to Dr. A. G. Jeetoo Hospital Regional Laboratory and to Queen Elizabeth Hospital Regional Laboratory, as per local practice.

Basic demographic and epidemiological information that will be collected include:

- Age
- Gender
- Medical record number
- Patient initials (patient names are not stored so as to de-identify the data)
- Specimen type

- Area or facility from which the specimen was taken
- Date the specimen was collected (or plated in the laboratory).

The 5 specimen types are pus swabs, endotracheal secretions (including tracheostomy tips and bronchoalveolar lavages), central venous catheter tips (including umbilical catheter and peripherally inserted central catheter tips), blood cultures and urine cultures.

The 8 priority pathogen and antimicrobial combinations are carbapenem-resistant *Acinetobacter baumannii*, carbapenem-resistant *Pseudomonas aeruginosa*, carbapenem-resistant *Klebsiella pneumoniae*, carbapenem-resistant *Escherichia coli*, carbapenem-resistant and colistin-resistant *Klebsiella pneumoniae*, vancomycin-resistant *Enterococcus sp*., methicillin-resistant *Staphylococcus aureus* and any *Candida auris*. Case definitions are in annex A.

During phase 2, carbapenem-resistant *Serratia marcescens* will be added.

Data is collected monthly and involves only the ICUs of the public sector (except for Rodrigues where the culture data from all sites are made available every 3 months) – details of the surveillance sites are in annex B. Thus, outbreak notifications are sent in the middle of each month. Moreover, trend analysis is carried out every 3 to 4 months, with feedback sent to MOHW, the National IPC Committee, the Regional IPC Teams and the Regional Health Directors.

During phase 2, data will be collected on a weekly basis and will involve all public healthcare facilities and wards.

Data are entered and analyzed electronically using Microsoft Excel. Given the complexity of the case definitions for hospital-acquired infections, none of the AMR data compiled will be used as a proxy for nosocomial infections.

Prior to data analysis, deduplication needs to be carried out – every month, only one result should be reported per patient per surveyed pathogen-antimicrobial combination.

Outbreak definitions

An outbreak is defined as an increase in the number of patients infected or colonized with an HPMDRO above the epidemic threshold within the same area with the threshold being defined as the mean incidence rate plus 1.96 standard deviations (i.e., above 95% of a 2-sided confidence interval or more than the 97.5% mark in a normal distribution). Outbreak thresholds are updated annually – see annex B for more information.

As from 2023, the minimum value of the threshold will be taken as 2 because single cases may occur in a sporadic manner without representing a serious public health threat. This follows international standard.[3]

Given that the CHL does not do wide genome sequencing on most bacteria, it is impossible to confirm the authenticity of outbreaks. As such, it appears impractical to notify an outbreak if 2 or more cases occur within 12 months (as used in some countries abroad) – a period of 1 week is in use in Mauritius for now since there is no international consensus on this issue.

The incubation period of MDRO is ill-defined and can go beyond 6 months.[4] While some countries again take the outbreak period to be 12 months, in Mauritius, for practical purposes, we use 6 months i.e., an outbreak is said to be persisting unless no new cases are identified in the last 6 months.

An HPMDRO is said to be endemic if an outbreak persists for more than 3 years in the same location – once more, no international consensus exists on this matter due to varying nuances based on the nature of the organisms, their lethality and their rates of spread.

Since it was noted in 2022 that alerts sent to regional IPC teams did not help to stop outbreaks from occurring, it is suggested that such warnings will no longer be forwarded to hospitals.

All outbreaks will be expected to be investigated by the regional IPC teams, sometimes with the help of additional staff from a national team or from the CHL.

Monitoring and Evaluation framework

The Monitoring and Evaluation indicators together with their definitions are shown in annex C.

While detailed targets are yet to be defined, the overall objective is to demonstrate a year-on-year decrease in the prevalence and incidence of AMR, to ensure that the prevalence of AMR for the nation is less than the global median and to reach an incidence rate of less 50 HPMDRO per 100 occupied beds per month at all locations.

General antimicrobial surveillance

In order to save human resources, this section is being appended to the NOHARM system so that a separate monitoring system is not developed in the future to assess organisms of national importance that are not multi-drug resistant.

For the purpose of diagnostic stewardship, it is proposed to add, during phase 2, the surveillance of coagulase negative staphylococcus in blood cultures.

To help with patient safety, monitoring of *Burkholderia cepacia* complex from blood cultures should also be performed, given the unhygienic way medications are prepared in the country.

References

1. Ministry of Health and Wellness, Mauritius. GLASS Report for the Years 2020 and 2021 for Mauritius. March 2023.
2. Ministry of Health and Wellness, Mauritius. Annual Progress Report on IPC for the Year 2022 at National Level. Jan 2023.
3. Oregon Health Authority, State of Oregon, USA. Guidelines for Investigating HAI Outbreaks – Basic Definitions. https://www.oregon.gov/oha/PH/DISEASESCONDITIONS/COMMUNICABLEDISEASE/HAI/REPORTING/Pages/MDRO-Investigative-Guidelines.aspx
4. Larsson AK, Gustafsson E, Nilsson AC, Odenholt I, Ringberg H, Melander E. Duration of methicillin-resistant *Staphylococcus aureus* colonization after diagnosis: a four-year experience from southern Sweden. Scand J Infect Dis. 2011 Jul;43(6-7):456-62.

Annex A
List of High Priority Multi-Drug Resistant Organisms

1. Carbapenem-resistant *Acinetobacter baumannii*
2. Carbapenem-resistant *Pseudomonas aeruginosa*
3. Carbapenem-resistant *Klebsiella pneumoniae*
4. Carbapenem-resistant *Escherichia coli*
5. Carbapenem-resistant *Serratia marcescens*
6. Carbapenem-resistant and colistin-resistant *Klebsiella pneumoniae*
7. Vancomycin-resistant *Enterococcus sp.*
8. Methicillin-resistant *Staphylococcus aureus*
9. *Candida auris*

Definitions

Organism	**Definition**
Carbapenem-resistant organism	Should be detected by the Central Health Laboratory or Dr. A. G. Jeetoo Regional Laboratory or Queen Elizabeth Regional Laboratory via the disc diffusion technique as non-susceptible in-vitro to meropenem, based on Clinical & Laboratory Standards Institute (CLSI) breakpoints. If the lab cannot identify the organism to the species level, then *Acinetobacter sp., Pseudomonas sp., Klebsiella sp.* and *Serratia sp.* will be counted.
Colistin-resistant *Klebsiella pneumoniae*	Should be detected by the Central Health Laboratory or Dr. A. G. Jeetoo Regional Laboratory or Queen Elizabeth Regional Laboratory via the disc diffusion technique as resistant in-vitro to colistin, based on CLSI breakpoints.
Vancomycin-resistant *Enterococcus sp.*	Should be detected by the Central Health Laboratory or Dr. A. G. Jeetoo Regional Laboratory or Queen Elizabeth Regional Laboratory via the disc diffusion technique or minimum-inhibitory concentration microdilution method as non-susceptible in-vitro to vancomycin, based on CLSI breakpoints.
Methicillin-resistant *Staphylococcus aureus*	Should be detected by the Central Health Laboratory or Dr. A. G. Jeetoo Regional Laboratory or Queen Elizabeth Regional Laboratory via the disc diffusion technique as non-susceptible in-vitro to oxacillin, based on CLSI breakpoints.
Candida auris	Should be identified by the Central Health Laboratory or Dr. A. G. Jeetoo Regional Laboratory using matrix-assisted laser desorption/ionization-time of flight.

Table 1: The term "resistant" implies "non-susceptible" in this context i.e., organisms with intermediate susceptibilities are taken as being resistant. One exception is susceptibility to colistin where an intermediate susceptibility is not the same as being resistant.

Annex B
Surveillance Sites for Phase 1 and Outbreak Thresholds for 2023

Locations	NOB	BOR †	NCM	Minimum number of weekly cases to meet outbreak threshold								
				CRAB	CRPA	CRKP	CCRKP	CRECOLI	VRE	MRSA	CAURIS	CRSM*
JH SICU	8	100%	25	8	3	6	2	2	2	2	2	2
JH NEURO ICU	8	100%	34	4	2	4	2	2	2	2	2	2
JH MICU	11	100%	17	2	2	2	2	2	2	2	2	2
JH NICU	5	100%	5	2	2	2	2	2	2	2	2	2
SSRNH ICU	9	100%	29	8	2	5	2	2	2	2	2	2
SSRNH NICU	5	100%	2	2	2	2	2	2	2	2	2	2
SSRNH NEW ICU	3	100%	5	2	2	2	2	2	2	2	2	2
BCH ICU	6	100%	18	6	2	2	2	2	2	2	2	2
BCH NICU	4	100%	2	2	2	2	2	2	2	2	2	2
JNH ICU	6	100%	26	4	3	2	2	2	2	3	2	2
JNH NICU	4	100%	3	2	2	2	2	2	2	2	2	2
VH ICU D4	10	100%	28	11	4	4	2	2	2	2	2	2
VH NICU	10	100%	6	4	2	2	2	2	2	2	2	2
VH ICU BURNS	5	60%	10	3	4	2	2	2	2	4	2	2
ENT COVID ICU	10	30%	14	2	2	2	2	2	2	2	2	2
QEH ICU	5	40%	1	2	2	2	2	2	2	2	2	2

*Table 2: Intensive Care Unit – ICU, neonatal ICU – NICU. Victoria Hospital - VH, Jawaharlal Nehru Hospital - JNH, Dr. A. G. Jeetoo Hospital - JH, Sir Seewoosagur Ramgoolam National Hospital – SSRNH, Dr. Bruno Cheong Hospital – BCH and Queen Elizabeth Hospital - QEH. Carbapenem-Resistant Acinetobacter baumannii – CRAB, Carbapenem-Resistant Pseudomonas aeruginosa – CRPA, Carbapenem-Resistant Klebsiella pneumoniae – CRKP, Carbapenem-Resistant and colistin-Resistant Klebsiella pneumoniae – CCRKP, Carbapenem-Resistant Escherichia coli – CRECOLI, Vancomycin-Resistant Enterococcus sp. – VRE, Methicillin-Resistant Staphylococcus aureus – MRSA, Candida auris – CAURIS and Carbapenem-Resistant Serratia marcescens - CRSM. * - Threshold was not calculated since baseline data is not available. NOB – No. Of Beds. BOR – mean Bed Occupation Rate. NCM – No. of Cultures positive for all the monitored organisms (susceptible or not) per Month in 2022 from the 5 surveyed sites (this is used as a relative marker of the total number of cultures performed at a location). † - estimated values. The total no. of cultures per month in the Island of Mauritius in the above locations are 221. The mean no. of occupied beds in the Island of Mauritius in the above locations is 95. The threshold is taken to be 2 for any other location outside those mentioned above.*

Annex C
Monitoring and Evaluation Indicators

To be evaluated in January of each year for the previous year

INDICATORS	DEFINITIONS
National Indicators on IPC	
Prevalence of HPMDRO in ICUs of the public sector (excluding Rodrigues)	$\frac{Number\ of\ HPMDRO\ from\ 5\ specimen\ sites\ in\ the\ 15\ public\ ICUs\ of\ the\ Island\ of\ Mauritius\ over\ a\ year}{Number\ of\ organisms\ under\ surveillance\ from\ 5\ specimen\ sites\ in\ the\ 15\ public\ ICUs\ of\ the\ Island\ of\ Mauritius\ over\ a\ year} * 100\%$
Incidence rate of HPMDRO in ICUs of the public sector per 100 beds per month adjusted for no. of cultures done (excluding Rodrigues)	$\frac{Number\ of\ HPMDRO\ from\ 5\ specimen\ sites\ in\ the\ 15\ public\ ICUs\ of\ the\ Island\ of\ Mauritius\ over\ a\ year}{(12\ months * 95\ beds * monthly\ number\ of\ cultures\ from\ the\ 5\ specimen\ sites\ positive\ for\ the\ organisms\ under\ surveillance) * 221\ cultures} * 100\ beds$
Number of outbreaks of HPMDRO in ICUs that are notified and investigated per year	Explicit
Bridging the 200 Gaps in IPC	
Prevalence of MRSA	$\frac{Number\ of\ MRSA\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year}{Number\ of\ Staphylococcus\ aureus\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year} * 100\%$
Prevalence of CRE	$\frac{Number\ of\ CRKP,\ CRECOLI\ and\ CRSM\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year}{Number\ of\ Klebsiella\ pneumoniae,\ Escherichia\ coli\ and\ Serratia\ marcascens\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year} * 100\%$
Prevalence of CRPA	$\frac{Number\ of\ CRPA\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year}{Number\ of\ Pseudomonas\ aeruginosa\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year} * 100\%$
Prevalence of CRAB	$\frac{Number\ of\ CRAB\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year}{Number\ of\ Acinetobacter\ baumannii\ from\ 5\ specimen\ sites\ from\ any\ location\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year} * 100\%$

IPC NAP 2022-2023	
Whether data is available electronically	Explicit
Whether non-ICU locations are included in the surveillance	Explicit
A National IPC Team is identified to supervise surveillance and outbreak investigations	Explicit
GLASS	
Percentage of *Acinetobacter sp.* from blood cultures that is resistant to meropenem in the ICU	$\frac{\begin{array}{c}Number\ of\ CRAB\ from\ blood\ cultures \\ from\ all\ ICUs\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Acinetobacter\ baumannii \\ from\ blood\ cultures\ from\ all\ ICUs \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Acinetobacter sp.* from blood cultures that is resistant to meropenem in non-ICU wards	$\frac{\begin{array}{c}Number\ of\ CRAB\ from\ blood\ cultures \\ from\ all\ non-ICU\ wards\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Acinetobacter\ baumannii \\ from\ blood\ cultures\ from\ all\ non-ICU\ wards \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Escherichia coli* from blood cultures that is resistant to ceftriaxone in the ICU	$\frac{\begin{array}{c}Number\ of\ Escherichia\ coli\ from\ blood\ cultures \\ that\ is\ resistant\ to\ ceftriaxone \\ from\ all\ ICUs\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ blood\ cultures\ from\ all\ ICUs \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Escherichia coli* from blood cultures that is resistant to ceftriaxone in non-ICU wards	$\frac{\begin{array}{c}Number\ of\ Escherichia\ coli\ from\ blood\ cultures \\ that\ is\ resistant\ to\ ceftriaxone \\ from\ all\ non-ICU\ wards\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ blood\ cultures\ from\ all\ non-ICU\ wards \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Klebsiella pneumoniae* from blood cultures that is resistant to meropenem in the ICU	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ blood\ cultures \\ from\ all\ ICUs\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ blood\ cultures\ from\ all\ ICUs \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Klebsiella pneumoniae* from blood cultures that is resistant to meropenem in non-ICU wards	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ blood\ cultures \\ from\ all\ non-ICU\ wards\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ blood\ cultures\ from\ all\ non-ICU\ wards \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$

Percentage of *Staphylococcus aureus* from blood cultures that is resistant to oxacillin in the ICU	$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ blood\ cultures \\ from\ all\ ICUs\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Staphylococcus\ aureus \\ from\ blood\ cultures\ from\ all\ ICUs \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Staphylococcus aureus* from blood cultures that is resistant to oxacillin in non-ICU wards	$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ blood\ cultures \\ from\ all\ non-ICU\ wards\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Staphylococcus\ aureus \\ from\ blood\ cultures\ from\ all\ non-ICU\ wards \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Streptococcus pneumoniae* from blood cultures that has high level resistance to penicillin (from any locations)	$\frac{\begin{array}{c}Number\ of\ Streptococcus\ pneumoniae \\ with\ high-level\ resistance \\ to\ penicillin\ from\ blood\ cultures \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Streptococcus\ pneumoniae \\ from\ blood\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Salmonella sp.* (non-typhi) from blood cultures that is resistant to ciprofloxacin (from any locations)	$\frac{\begin{array}{c}Number\ of\ non-typhi\ Salmonella \\ from\ blood\ cultures\ that\ is\ resistant \\ to\ ciprofloxacin \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ non-typhi\ Salmonella \\ from\ blood\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Escherichia coli* from urine cultures that is resistant to ceftriaxone in the outpatient	$\frac{\begin{array}{c}Number\ of\ Escherichia\ coli\ from\ urine\ cultures \\ that\ is\ resistant\ to\ ceftriaxone \\ from\ all\ outpatients\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ urine\ cultures\ from\ all\ outpatients \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Klebsiella pneumoniae* from urine cultures that is resistant to meropenem in the outpatient	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ urine\ cultures \\ from\ all\ outpatients\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ urine\ cultures\ from\ all\ outpatients \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Neisseria gonorrheae* from genital swab cultures that is resistant to ceftriaxone (from any locations)	$\frac{\begin{array}{c}Number\ of\ Neisseria\ gonorrheae \\ from\ genital\ cultures \\ that\ is\ resistant\ to\ ceftriaxone \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Neisseria\ gonorrheae \\ from\ genital\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$

Percentage of *Salmonella sp.* (non-typhi) from stool cultures that is resistant to ciprofloxacin (from any locations)	$\frac{\begin{array}{c}Number\ of\ non-typhi\ Salmonella \\ from\ stool\ cultures\ that\ is\ resistant \\ to\ ciprofloxacin \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ non-typhi\ Salmonella \\ from\ stool\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Sustainable Development Goals	
Percentage of *Staphylococcus aureus* from blood cultures that is resistant to oxacillin (from any locations)	$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ blood\ cultures \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Staphylococcus\ aureus \\ from\ blood\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
Percentage of *Escherichia coli* from blood cultures that is resistant to ceftriaxone (from any locations)	$\frac{\begin{array}{c}Number\ of\ Escherichia\ coli\ from\ blood\ cultures \\ that\ is\ resistant\ to\ ceftriaxone \\ in\ the\ Republic \\ of\ Mauritius\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ blood\ cultures \\ in\ the\ Republic\ of\ Mauritius\ over\ a\ year\end{array}} * 100\%$
NOHARM System	
Prevalence of CRAB in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRAB\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Acinetobacter\ baumannii \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRAB in non-ICU wards disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRAB\ from\ 5\ specimen\ sites \\ in\ the\ non-ICU\ wards\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Acinetobacter\ baumannii \\ from\ 5\ specimen\ sites\ in\ the\ non-ICU\ wards \\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRKP in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRKP outside of ICU disaggregated by region	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ 5\ specimen\ sites \\ outside\ the\ ICUs\ of\ a\ specific\ region \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ 5\ specimen\ sites\ outside\ the\ ICUs\ of \\ a\ specific\ region \\ over\ a\ year\end{array}} * 100\%$

Prevalence of CCRKP in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CCRKP\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Klebsiella\ pneumoniae \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRPA in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRPA\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Pseudomonas\ aeruginosa \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRPA in non-ICU wards disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRPA\ from\ 5\ specimen\ sites \\ in\ the\ non-ICU\ wards\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Pseudomonas\ aeruginosa \\ from\ 5\ specimen\ sites\ in\ the\ non-ICU\ wards \\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRECOLI in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRECOLI\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRECOLI outside of ICU disaggregated by region	$\frac{\begin{array}{c}Number\ of\ CRECOLI\ from\ 5\ specimen\ sites \\ outside\ the\ ICUs\ of\ a\ specific\ region \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Escherichia\ coli \\ from\ 5\ specimen\ sites\ outside\ the\ ICUs\ of \\ a\ specific\ region \\ over\ a\ year\end{array}} * 100\%$
Prevalence of VRE in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ VRE\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Enterococcus\ sp. \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of VRE outside of ICU disaggregated by region	$\frac{\begin{array}{c}Number\ of\ VRE\ from\ 5\ specimen\ sites \\ outside\ the\ ICUs\ of\ a\ specific\ region \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Enterococcus\ sp. \\ from\ 5\ specimen\ sites\ outside\ the\ ICUs\ of \\ a\ specific\ region \\ over\ a\ year\end{array}} * 100\%$
Prevalence of MRSA in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Staphylococcus\ aureus \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$

Prevalence of MRSA outside of ICU disaggregated by region	$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ 5\ specimen\ sites \\ outside\ the\ ICUs\ of\ a\ specific\ region \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Staphylococcus\ aureus \\ from\ 5\ specimen\ sites\ outside\ the\ ICUs\ of \\ a\ specific\ region \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CAURIS in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CAURIS\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Candida\ sp. \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CAURIS in non-ICU wards disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CAURIS\ from\ 5\ specimen\ sites \\ in\ the\ non-ICU\ wards\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Candida\ sp. \\ from\ 5\ specimen\ sites\ in\ the\ non-ICU\ wards \\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Prevalence of CRSM in the ICU disaggregated by hospital	$\frac{\begin{array}{c}Number\ of\ CRSM\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}Number\ of\ Serratia\ marcescens \\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}} * 100\%$
Adjusted incidence rate of CRAB in the ICU disaggregated by hospital (per 100 occupied beds per month)	$\frac{\begin{array}{c}Number\ of\ CRAB\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds$ $* \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$
Adjusted incidence rate of CRKP in the ICU disaggregated by hospital (per 100 occupied beds per month)	$\frac{\begin{array}{c}Number\ of\ CRKP\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds$ $* \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$

Adjusted incidence rate of CCRKP in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{\begin{array}{c}Number\ of\ CCRKP\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds * \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$$
Adjusted incidence rate of CRPA in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{\begin{array}{c}Number\ of\ CRPA\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds * \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$$
Adjusted incidence rate of CRECOLI in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{\begin{array}{c}Number\ of\ CRECOLI\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds * \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$$
Adjusted incidence rate of VRE in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{\begin{array}{c}Number\ of\ VRE\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds * \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$$
Adjusted incidence rate of MRSA in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{\begin{array}{c}Number\ of\ MRSA\ from\ 5\ specimen\ sites \\ in\ the\ ICUs\ of\ a\ hospital \\ over\ a\ year\end{array}}{\begin{array}{c}(12\ months * \sum_{Per\ ICU}(No.of\ beds * BOR) * \\ \sum_{Per\ ICU} monthly\ number\ of\ cultures \\ from\ the\ 5\ specimen\ sites\ positive\ for \\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}\end{array}} * 100\ beds * \sum_{Per\ ICU} No.of\ cultures\ in\ 2022$$

Adjusted incidence rate of CAURIS in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{Number\ of\ CAURIS\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital\ over\ a\ year}{(12\ months * \sum_{Per\ ICU}(No.\ of\ beds * BOR) * \sum_{Per\ ICU} monthly\ number\ of\ cultures\ from\ the\ 5\ specimen\ sites\ positive\ for\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}} * 100\ beds * \sum_{Per\ ICU} No.\ of\ cultures\ in\ 2022$$
Adjusted incidence rate of CRSM in the ICU disaggregated by hospital (per 100 occupied beds per month)	$$\frac{Number\ of\ CRSM\ from\ 5\ specimen\ sites\ in\ the\ ICUs\ of\ a\ hospital\ over\ a\ year}{(12\ months * \sum_{Per\ ICU}(No.\ of\ beds * BOR) * \sum_{Per\ ICU} monthly\ number\ of\ cultures\ from\ the\ 5\ specimen\ sites\ positive\ for\ the\ organisms\ under\ surveillance)_{for\ a\ hospital}} * 100\ beds * \sum_{Per\ ICU} No.\ of\ cultures\ in\ 2022$$
Number of locations with adjusted incidence rate of HPMDRO > 50 per 100 occupied beds per month	Explicit
A report is sent to MOHW every year on the indicators of NOHARM	Explicit
A trend analysis on HPMDRO rates is made at least 3 times a year and submitted to the NIC	Explicit
Outbreaks are identified at least monthly, and notifications are sent to the respective hospitals	Explicit
General Antimicrobial Surveillance	
Number of wards (including ICUs) with an on-going outbreak of *Burkholderia cepacia* complex from blood cultures disaggregated by hospital	Explicit
Percentage of blood cultures with coagulase negative staphylococcus disaggregated by hospital	$$\frac{Number\ of\ blood\ cultures\ positive\ for\ coagulase\ negative\ staphylococcus\ in\ a\ hospital\ over\ a\ year}{Total\ number\ of\ blood\ cultures\ done\ at\ a\ hospital\ over\ a\ year}$$

Table 3: IPC – Infection Prevention and Control. HPMDRO – High-Priority Multi-Drug Resistant Organisms. Intensive Care Unit – ICU. BOR – mean Bed Occupancy Rate. NAP – National Action Plan. NIC – National IPC Committee. MOHW – Ministry of Health and Wellness. GLASS – Global Antimicrobial Resistance Surveillance System. Carbapenem-Resistant Acinetobacter baumannii – CRAB, Carbapenem-Resistant Pseudomonas aeruginosa – CRPA, Carbapenem-Resistant Klebsiella pneumoniae – CRKP, Carbapenem-Resistant and colistin-Resistant Klebsiella pneumoniae – CCRKP, Carbapenem-Resistant Escherichia coli – CRECOLI, Vancomycin-Resistant Enterococcus sp. – VRE, Methicillin-Resistant Staphylococcus aureus – MRSA, Candida auris – CAURIS and Carbapenem-Resistant Serratia marcescens - CRSM. The terms "all ICUs" and "all non-ICU wards" means all such sites that are being monitored. Non-ICU wards excludes the casualty, outpatient and day care centers i.e., this term includes only places where patients can be admitted overnight. CRKP includes CCRKP during calculations. See annex A for the organisms under surveillance and the main text for the specimen sites.