ACINETOBACTER BAUMANNII OUTBREAK IN NICU AT THE COLONIAL WAR MEMORIAL HOSPITAL SUVA, FIJI, DECEMBER 2016 – JULY 2017

Technical report

11 July 2017 – 9 August 2017

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LIST OF ABBREVIATIONS

AMS	Antimicrobial stewardship
CHW	Children's ward
CSF	Cerebrospinal fluid
CSSD	Central sterilizing supply department
CSU	Catheter specimen of urine
CVC	Central venous catheter
CWMH	Colonial War Memorial Hospital
DoA	Date of admission
DoB	Date of birth
DoFPS	Date of first positive specimen
ETT	Endotracheal tube
FPBS	Fiji Pharmaceutical and Biomedical Services
GOARN	Global Outbreak Alert and Response Network
HAI	Healthcare associated infection
ICC	Infection Control Committee
IPC	Infection prevention and control
IPCP	Infection prevention and control program
MOHMS	Ministry of Health and Medical Services
MDRAB	Multi drug resistant *Acinetobacter baumannii*
MDRO	Multi drug resistant organism
MDU-PHL	Microbiological Diagnostic Unit Public Health Laboratory
NICU	Neonatal intensive care unit
OGT	Orogastric tube
OT	Operating Theatre
PICU	Paediatric intensive care unit
SCM	Supply chain management
SXT	Trimethoprim- sulfamethoxazole
UVC	Umbilical venous catheter
WPRO	Western Pacific Regional Office of WHO
WHO	World Health Organization

MISSION BACKGROUND

The Fiji Ministry of Health and Medical Services (MOHMS) requested the support of WHO to investigate 12 neonatal intensive care unit (NICU) patients at the Colonial War Memorial Hospital (CWMH) in Suva with *Acinetobacter baumannii* resistant to all tested antibiotics (referred to as AB investigation strain in this report). The 12 cases were reported by the MOHMS as having occurred in two clusters from 13 December 2016 – 26 February 2017 and 27 May – 23 June 2017. The AB investigation strain was isolated in the blood or cerebrospinal fluid (CSF) samples from these patients, all of whom died.

The purpose of the Global Outbreak Alert and Response Network (GOARN) mission was to assist with the epidemiological investigation of the outbreak of multi-drug resistant *A. baumannii* (MDRAB) in the NICU at the CWMH. A review of the infection prevention and control (IPC) practices at the CWMH and hospitals in Lautoka and Labasa was to be conducted at the same time as requested by the MOHMS.

TERMS OF REFERENCE

These are the specific terms of reference for the mission:

Outbreak investigation

1. Literature review of published and/or unpublished data and studies that will assist with collection of information relevant to the current review of MDRAB cases in CWMH.
2. Review the case records and line listing of the cases from the two recent NICU clusters, and collect any additional data needed for the epidemiological investigation
3. Conduct a retrospective audit of sterile site infections among admissions to NICU at CWMH since Jan 2015
4. Review the surveillance system for health care associated infections at CWMH and specifically in NICU and Paediatric Intensive Care Unit (PICU)
5. If required, extend these investigations to adult Intensive Care Unit (ICU**.**

Review of Infection Prevention and Control (IPC) practices and antimicrobial stewardship

1. Review current IPC policy and audit IPC practices at CWMH, with a focus on NICU and other high dependency wards
2. Conduct a retrospective review of restricted antibiotics usage and prescribing practices
3. Identify any risks for the spread of MDRAB posed by engineering controls[1], IPC policies and procedures, staff movements, work practices in NICU and other high dependency wards
4. In collaboration with the hospital pharmacy, review supply chain management of essential drugs, materials and supplies for antimicrobial stewardship and good IPC practice
5. Review the current Terms of Reference, membership and procedures of the IPC Committee
6. Conduct ward visits and interview CWMH staff and other key informants

[1] Engineering controls of the physical environment aim to reduce the concentration of infectious agents in the environment and the likelihood of their spread. They include, but are not limited to, the physical layout of the facility, adequate environmental ventilation, the spatial separation between patients, and facilities for hand washing and hand hygiene.

7. Conduct training and presentations to key health workers including the CWMH IPC Committee members
8. Interview World Health Organization (WHO) technical staff, including verification/validation of collated information
9. Synthesise and summarise information gathered in a detailed report, including key conclusions and recommendations
10. Provide a debriefing to the CWMH IPC Committee and senior management, Ministry of Health and Medical Services senior executives, and WHO

Amendments to Terms of Reference (TORs):

On 13 July 2017, the TORs were amended following a discussion between WHO and the consultants with the aim of clarifying the intent and feasibility of activities described in the original TORs. For example, the original TOR #3 was changed from "Conduct a retrospective audit of sterile site infections in patients admitted to NICU at CWMH since Jan 2015" to that defined in TOR #3 below. What was in and out of scope of TOR #4 was also better defined. These changes did not affect either the overall intent or focus of the GOARN mission.

Outbreak investigation:

TOR #3. Conduct a count of the number of *Acinetobacter baumannii* and *Klebsiella pneumoniae* infections in blood stream infections (and possibly other sterile sites if such data is readily available) in NICU since Jan 2015, to establish a baseline for the current NICU outbreak.

TOR #5. As required, extend the investigations to count *Acinetobacter baumannii* and *Klebsiella pneumoniae* infections in the PICU and ICU.

Review of IPC practices and antimicrobial stewardship

TOR #4. The team will not be able to do a detailed review of supply chain management (SCM) of essential drugs and antimicrobial stewardship (AMS) but will conduct interviews with pharmacists and Fiji Pharmaceutical and Biomedical Services Centre (FPBS) staff in order to understand the current procurement and supply system in place. There are currently two Australian pharmacists working on AMS with FPBS and CWMH over a 12 month period, and as such are better placed to address these issues than the GOARN team during the short mission.

GOARN TEAM

Name	Dr Peta-Anne Zimmerman
Institution	Griffith University/Gold Coast Hospital and Health Service/Menzies Health Institute, Queensland/Australasian College for Infection Prevention and Control
Role in team	Infection Prevention and Control Consultant Conduct review of IPC practices at CWMH, Lautoka and Labasa hospitals Training of IPC team
Location	Suva, Lautoka, Labasa
Time in country	12 July - 24 July 2017

Name	Dr Meghan Lyman
Institution	US Centers for Disease Control and Prevention

Role in team	Epidemiologist Conduct epidemiological investigation of NICU outbreak at CWMH Assist in review of IPC practices at CWMH Training of IPC team and NICU staff
Location	Suva
Time in country	11 July - 3 Aug 2017

Name	Dr Patiyan Andersson
Institution	National Centre for Epidemiology and Population Health, Australian National University
Role in team	Epidemiologist Conduct epidemiological investigation of NICU outbreak at CWMH Assist in review of IPC practices at CWMH Assist in training of IPC team and NICU staff
Location	Suva
Time in country	12 July - 9 Aug 2017

OBJECTIVES

Overall objectives of the mission:

- Outbreak investigation
- Review of IPC practices and antimicrobial stewardship

Outputs:

- MDRAB situation analysis and audit report
- Key health workers and IPC Committee members trained on IPC practices and outbreak interventions
- Final technical report with key findings and recommendations

GOARN TEAM ACTIVITIES

Summary of GOARN team activities (**Annexes 1 and 2** provide the details)

- Epidemiological investigation of outbreak in NICU at CWMH (M. Lyman and P. Andersson)
- Review of Infection Prevention and Control capacity in Fiji in collaboration with relevant IPC teams (Lead by P-A. Zimmerman, assisted at CWMH by M. Lyman and P. Andersson)
- Provision of guidance at divisional hospital and national levels (P-A. Zimmerman, M. Lyman and P. Andersson)
- Ensuring key stakeholder agreement to IPC implementation work plan (P-A. Zimmerman, M. Lyman and P. Andersson)
- Workshops with IPC team at CWMH (Lead by P-A. Zimmerman, assisted by M. Lyman and P. Andersson)
- Collaboration with key stakeholders and Infection Control Committees at each facility
- Provision of locally relevant feedback at each facility (P-A. Zimmerman)
- Review, evaluation, and reporting of IPC at Lautoka Hospital (P-A. Zimmerman)
- Review, evaluation, and reporting of IPC at Labasa Hospital (P-A. Zimmerman)
- Review, evaluation, and reporting of IPC at CWMH (P-A. Zimmerman, M. Lyman and P. Andersson)
- Workshops conducted at CWMH with IPC team (P-A. Zimmerman, M. Lyman and P. Andersson)
- Development of workplan for IPC implementation with CWMH IPC team (P-A. Zimmerman)
- On-site guidance on improving IPC practices at CWMH NICU (M. Lyman)

- Development of workplan for improving IPC practices in NICU at CWMH (M. Lyman)
- Development of electronic databases and analysis components for ongoing MDRO surveillance with IPC team (P. Andersson)
- Briefing of Permanent Secretary of Health and Ministry of Health and Medical Services (MOHMS) partners (P-A. Zimmerman, M. Lyman and P. Andersson)
- Development of reports documenting investigation (P-A. Zimmerman, M. Lyman and P. Andersson)

ACKNOWLEDGEMENTS

Many thanks to all who organised this mission in the WHO HQ GOARN Operations Support Team, WHO South Pacific Office | Division of Pacific Technical Support, WHO Western Pacific Regional Office (WPRO) and the Ministry of Health and Medical Services of Fiji. Special thanks to the in-country counterparts who we respect and acknowledge for their expertise and assistance.

We would also like to acknowledge the support from our home institutions, Griffith University, US Centers for Disease Control and Prevention and the Australian National University for their invaluable input during the course of the investigation, and the Microbiological Diagnostic Unit Public Health Laboratory, Peter Doherty Institute for Infection and Immunity, University of Melbourne which conducted the full genome sequencing of the clinical specimens.

1. EXECUTIVE SUMMARY

From December 2016 to June 2017, the Colonial War Memorial Hospital (CWMH) in Suva, Fiji, identified 12 neonatal intensive care unit (NICU) patients with *Acinetobacter baumannii* resistant to all tested antibiotics isolated from blood or cerebrospinal fluid (CSF) samples (referred to as the AB investigation strain throughout this report). All 12 patients died. These 12 case-patients were reported by CWMH as having occurred in two clusters from 13 December 2016 – 26 February 2017 and 27 May – 23 June 2017. The purpose of the GOARN mission from 11 July – 9 August 2017 was to assist with the epidemiological investigation of the outbreak and to conduct a review of the infection prevention and control (IPC) practices at the CWMH and hospitals in Lautoka and Labasa as requested by the Fiji Ministry of Health and Medical Services (MOHMS).

The epidemiological and laboratory investigations revealed an *A. baumannii* strain resistant to all tested antibiotics including meropenem, which was more common in the NICU than other paediatric wards. Along with a rise in the number of patients testing positive for this strain, there had been an increase in invasive infections and deaths among these patients.

A review of admissions to the NICU and paediatric ICU (PICU) from 1 December 2016 – 31 July 2017 identified two additional patients with the AB investigation strain considered part of the second cluster, bringing the total to 14 patients with this strain of *A. baumannii* in blood or CSF specimens (sterile site infections). Nine blood culture isolates and 5 cerebrospinal fluid isolates from 11 of these patients were sent to the Microbiological Diagnostic Unit Public Health Laboratory, University of Melbourne in Australia for whole genome sequencing, with 3 patients having samples from both sites sent for testing. Multilocus sequence typing (MLST) of the isolates showed 14 belonging to sequence type 2 (ST2) genotype but two different sub-groups clustering by sample collection date based on whole genome sequencing, with one group evolving from the other.

In addition, 20 patients tested positive for the AB investigation strain on specimens collected from sites other than blood and CSF. While these case-patients were very ill on admission to the ICU, many did not have cultures positive for this strain on admission. While respiratory conditions and ventilator support were observed for nearly all for case-patients, many of the other characteristics and exposures of these case-patients varied.

In collaboration with the Infection Control Committees and staff of the Colonial War Memorial, Lautoka, Labasa Hospitals, an evaluation of IPC policies, practices and infrastructure was conducted at each facility using a standardised assessment tool. Findings indicated systemic infrastructure issues not conducive to support effective and consistent IPC practices due to the unreliable supply of: single patient use respiratory equipment leading to inappropriate and unsafe reprocessing of patient care items; personal protective equipment; intravenous fluids, medication and associated equipment; and hand hygiene equipment and supplies. Associated with, but not limited to these findings is: the need for greater leadership support; inconsistent cleaning methodologies; and non-specific healthcare associated infection and hand hygiene surveillance. The findings of the current investigation are consistent with reports from similar outbreaks spanning 10 years.

The varied exposures of these case-patients and the multiple infection control gaps identified suggest that cross-contamination likely resulted in multiple sources of transmission within the ICUs, rather than one point-source of transmission of the *A. baumannii* investigation strain. Improving implementation of IPC practices, especially hand hygiene, contact precautions, environmental cleaning, and equipment decontamination, will prevent ongoing transmission of *A. baumannii* and other organisms in the paediatric

ICUs and hospital-wide. An appropriate and uninterrupted supply of personal protective equipment, other IPC equipment and supplies, and the equipment and consumables needed for individual patient care, is essential for good IPC practice.

It is recommended that there be a consistent commitment, not only at a NICU or facility level but at a whole of health service level, to support and strengthen IPC practice in the delivery of safe care through appropriate supply management and strong and consistent leadership in IPC. A work plan to this end was developed in collaboration with the MOHMS, Infection Control Committees, and staff identifying clear and achievable short, medium, and long-term goals for remediation across the whole health sector. In order to effect long term and sustainable improvements IPC practices, linkage with other health systems strengthening approaches is needed.

2. INTRODUCTION

Healthcare-associated infections (HAI) due to *A. baumannii,* a highly resilient bacterium capable of surviving for extended time on surfaces, are often associated with invasive devices or contaminated environment. Outbreaks of multi-drug resistant organisms (MDROs) in NICUs occur in a patient population that does not have many of the risk factors often associated with MDROs, including prior antibiotic use, hospital admission, or other exposure to healthcare.

There are few publications describing the antimicrobial resistance in Fiji hospitals, but data published thus far have described a high prevalence of *A. baumannii*. Naidu *et al* investigated nosocomial infections in the ICU at CWMH during 2011-12, and described the most common species in respiratory and blood specimens which were *Klebsiella pneumoniae* and *A. baumannii*.[1] Mortality was noted to be very high among these patients, and 55% of those who died had a blood stream infection. Kumar *et al* studied bacterial isolates from neonates with suspected sepsis at the CWMH in 2012, and found that *E. coli*, *K. pneumoniae* and *A. baumannii* were the most common bacteria isolated.[2] Mortality was highest in patients with bacteria isolated from blood or from an endotracheal tube.

CWMH is the largest hospital in Fiji, with 514 beds and often operating at full occupancy. CWMH provides the only NICU in the central division of Fiji (population of 342,000 in 2007) with 30 beds and approximately 500 admissions per year and also serves as the referral centre for Fiji. CWMH has 550-850 childbirths per month, but has noticed a recent increase in the number of deliveries.

The NICU consists of 4 wards: one designated for the most severely ill patients; one designated as a step-down unit for slightly less severely ill patients; one to receive neonates from outside hospitals awaiting screening culture results prior to NICU admission; and one for preterm or underweight (but otherwise well) neonates and their mothers. There is a total 9-10 nurses staffing these 4 NICU rooms per shift. While equipment is designated for NICU use, there is some equipment that may be occasionally shared with other paediatric units (i.e. ventilators and infusion pumps can be shared with PICU).

After identifying a potential outbreak of 12 patients with *A. baumannii* in blood or CSF in the CWMH NICU from December 2016 to June 2017, the MOHMS requested assistance from WHO to conduct an epidemiological investigation. The CWMH Infection Control Committee identified the infections as having occurred in two distinct clusters from clusters from 13 December 2016 – 26 February 2017 (7 cases) and 27 May – 23 June 2017 (5 cases). The objectives of the investigation were to identify potential risk factors or exposures associated with these infections and simultaneously conduct an infection control assessment of the three referral hospitals (CWMH, Lautoka and Labasa Hospitals) to identify any gaps in IPC.

Subsequent to a request for assistance to WHO-DPS, a GOARN team was assembled and deployed to perform these two objectives in parallel. In addition, WHO coordinated with the Microbiological Diagnostic Unit Public Health Laboratory, Peter Doherty Institute for Infection and Immunity, University of Melbourne, to conduct whole genome sequencing of *A. baumannii* isolates and carry out a phylogenetic analysis.

3. METHODS AND DATA SOURCES

3.1 EPIDEMIOLOGICAL INVESTIGATION

3.1.1 Case finding

Following the identification of the first cases of multi-drug resistant *A. baumannii* cases in December 2016, screening specimens from blood, urine, and rectal swabs have been collected from all patients on admission to NICU. Additional specimens are collected as clinically indicated for suspected infection during the admission.

The CWMH microbiology laboratory performs culturing, isolation, and antimicrobial susceptibility testing of *A. baumannii*. The panel of antibiotics routinely tested for *A. baumannii* includes Ampicillin, Doxycycline, Chloramphenicol, Trimethoprim-sulfamethoxazole (SXT), Gentamycin, Cephalothin, Ceftriaxone, Ciprofloxacin, Amikacin and Meropenem, but Colistin can be tested upon clinician request. If the microbiology lab detects any isolate resistant to 4 of 5 first-line antibiotics (Ampicillin, Chloramphenicol, SXT, Gentamycin or Cephalothin), it characterizes it as a multidrug-resistant organism (MDRO) and alerts the IPC team who documents these results in a MDRO log.

To conduct case-finding and establish a baseline of the occurrence of multidrug-resistant *A. baumannii* in the CWMH NICU, the GOARN team reviewed the IPC team MDRO log for paediatric patients to identify all specimens positive for *A. baumannii* collected from 1 January 2015 to 31 July 2017. This information was used to determine whether there was an increase in patients with positive specimens and develop a case definition used to gather more detailed patient information.

3.1.2 Case definitions

For this investigation, the GOARN team developed the following case definitions:

- An invasive case was defined as a blood or CSF specimen positive for the AB investigation strain (resistant to all tested antibiotics) collected from a patient in a paediatric ICU (NICU or PICU) from 1 December 2016 to 31 July 2017.
- A less-invasive case was defined as a specimen other than blood or CSF which was positive for the AB investigation strain based on an identical antibiotic sensitivity profile collected from a patient in a paediatric ICU (NICU or PICU) from 1 December 2016 –31 July 2017. This case definition does not include clinical signs or symptoms and includes both patients that qualify as being infected and colonized.[2]

3.1.3 Epidemiological analysis

Epidemiological data were collected from invasive and less-invasive case-patients' medical charts. Data were collected on patient demographics, illness information (e.g. symptoms, date of illness or sepsis onset, use of inotropes, procedures, use of total parenteral nutrition (TPN), blood transfusions), invasive devices, (central catheters, urinary catheters, mechanical ventilation), clinical outcomes, antibiotic treatment and laboratory specimen results. For neonates, data were also collected on perinatal and delivery history (e.g. type of delivery, delivery complications, evidence of prolonged rupture of the membranes, requirement of positive pressure ventilation or resuscitation at delivery), neonate information (e.g. gestational age,

[2] Colonization is the culture of the AB investigation strain from a body surface specimen, e.g. skin, mouth, rectum or airway, without causing clinical evidence of disease in the patient.

birthweight, diagnoses or comorbidities, feeding), and maternal information (e.g. antenatal care, comorbidities, prior admissions or antibiotics). Most of the maternal charts were unavailable so epidemiological data on the case-patients' mothers or prenatal/perinatal exposures were limited.

3.1.4 Environmental sampling

Environmental sampling was conducted in June by CWMH during the second cluster of cases, including samples from a sink, ventilator, TPN, and distilled water, but details about how these samples were collected were not available. Environmental testing of TPN and distilled water were subsequently repeated. All environmental samples were processed by the microbiology laboratory, but methods specific for environmental sampling were not used (i.e. methods to compensate for low bacterial load or 'destructive sampling' recommended to test biofilms as sources of transmission).

3.1.5 Whole genome sequencing

Fifteen blood or CSF samples from the 12 patients initially identified as part of the outbreak were sent to the Microbiological Diagnostic Unit Public Health Laboratory (MDU-PHL) at the University of Melbourne, Australia, for whole genome sequencing to assess relatedness of these strains. Three patients had both blood and CSF collected.

3.2 INFECTION PREVENTION AND CONTROL EVALUATION

Description of assessment tool (**Annex 3**)

The purpose of the evaluation at the CWMH, Lautoka and Labasa Hospitals using the Infection Prevention and Control Programme Evaluation tool (Annex 3) was to provide an assessment of the status of the infection prevention and control program (IPCP) and healthcare IPC activities in a given healthcare facility. The assessment tool used does not consider the risk of individual patients or specific cases nor other aspects related to care outside of surveillance, prevention, and control of health care associated infections (HAI). It should not be considered an accreditation system; however, the tool may be used internally as a continuous quality improvement activity or as an external review tool by appropriately qualified IPC technical consultants.

This evaluation tool is an adaptation of the "Nosocomial Infection Program Rapid Evaluation Guide" created by the Pan American Health Organization and the "Audit Tools for Monitoring Infection Control Standards" from the Infection Control Nurses Association. To comprehensively evaluate an IPCP it is essential to examine both theoretical and practical aspects. This tool combines those most essential standards of an IPCP including how policy and guidelines translate into the healthcare environment and patient care.

The evaluation provides information on a number of aspects that should be included in an IPCP. These aspects have been organized in eight areas that include similar topics. In each area, some components considered being essential in a good program have been selected. In each component, standards have been established to best describe an acceptable component. Then, indicators have been established so that the presence of the standards could be considered objectively. A single standard may have several indicators and a single component may have several standards. Space has been provided for each indicator to enter what source was used to verify its presence.

A list of suggested verifiers is provided. These simply offer orientation or sources of information for the evaluator/s that can be used to determine whether a certain indicator is present. The evaluator/s can use other methods to establish the presence of indicators. A glossary is also provided to assist with clarification

of terms used. According to this tool, evaluation of the IPCP is based solely on the presence of indicators. Some of these indicators can only be assessed by observation of the clinical situation. Full methodology on how the evaluation tool is applied can be found in **Annex 3**.

Infection prevention and control program evaluations were conducted at Lautoka, Labasa and CWMH. Feedback from these evaluations was provided to each facility verbally to the senior staff and Medical Superintendents, with a completed copy of the evaluation (**Annexes 4-6**). Workshops were conducted at the CWMH with the Infection Prevention and Control team on:

1. Healthcare associated surveillance strategies, with a targeted surveillance plan produced (see recommendations in Section 7)
2. Infection control liaison/link nurse program implementation plan
3. Development of short, medium, and long-term goals for the IPC programs throughout Fiji (see Section 7). This was presented to the Permanent Secretary of Health and to MOH key stake holders (presentation slides included as **Annex 9**).

4. RESULTS

4.1 EPIDEMIOLOGICAL INVESTIGATION

4.1.1 Case finding

There was a total of 173 MDRAB isolates collected from 127 patients from 1 January 2015 to 31 July 2017. The frequency of MDRAB isolates per month demonstrates an increase starting in December 2016 for both the NICU and PICU (**Figure 1**). Several different AST patterns were identified, including ones that were sensitive to meropenem (n=54), ones that were resistant to meropenem but sensitive to other antibiotics (n=15), and ones that were resistant to all antibiotics tested (AB investigation strain, n=102). For two isolates the sensitivity to meropenem was not available.

Figure 1 demonstrates differences in the distribution of the different strains between the paediatric ICUs (NICU and PICU). *A. baumannii* isolates sensitive to meropenem were more common in the PICU, while the highly resistant AB investigation strain was more common in the NICU. Sporadic specimens collected from NICU patients with the AB investigation strain indicate that it occurred as early as January 2015. The number of all specimens, and specifically blood and CSF specimens, positive for the AB investigation strain, increased from December 2016; increased testing until July 2017 in response to the outbreak may account for some of the increase observed. It should be noted that the PICU specimens positive for the AB investigation strain were collected during the same time as the NICU outbreak. The children's ward had very few *A. baumannii* isolates (n=11), all but one of which were sensitive to meropenem. In December 2015, one sample showed multidrug resistance.

A total of 40 patients were identified by review of the MDRO log book using the investigation case definitions; 33 patients from NICU and 7 patients from PICU. Among the 40 case-patients, the GOARN team was unable to locate the patient charts for 2 NICU and 4 PICU patients, resulting in a total of 34 patients (31 NICU and 3 PICU) included in the epidemiological analysis. **Table 1** presents the line listing of the 34 case-patients for whom clinical data were available, of whom 14 were classified as invasive cases and 20 as less-invasive cases. One case-patient included in the analysis was still in the NICU at the time of writing the report.

When the case definition was applied to the patients originally identified as part of the outbreak, one of these patients did not qualify as an invasive case because s/he had an *A. baumannii* strain sensitive to

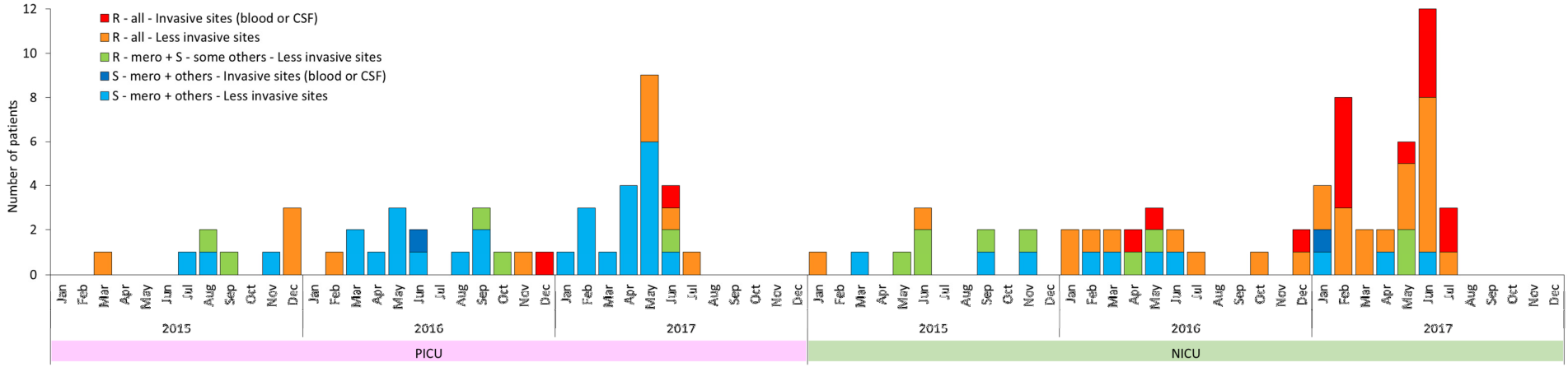
several antibiotics including meropenem isolated from the blood; however, the AB investigation strain isolated from a longline tip.

From 1 December 2016 to 31 July 2017, there were 293 admissions to NICU and 164 admissions to PICU, meaning that the proportion of patients with the AB investigation strain was 10.6% for NICU and 1.8% for PICU. The invasive cases were observed to form two clusters from over the outbreak period from 13 December 2016 to 23 June 2017. However, as shown in **Table 2**, there were patients with the AB investigation strain present in the NICU throughout the outbreak period.

4.1.2 Microbiological description of the cases

Among the 34 case-patients, a total of 74 specimens were positive for the AB investigation strain. The specimen types for individual patients can be found in **Table 1**. The most common specimen type positive for AB investigation strain was endotracheal tubes tips or aspirates (29/78, 37%) followed by blood samples (12/78, 15%).

Figure 1 - Patients with specimen positive for *Acinetobacter baumannii* in paediatric wards at the CWMH, from 1 January 2015 – 31 July 2017



Only the most invasive positive specimen is shown for each patient, unless two specimens have isolates with different antimicrobial resistance profiles, in which case both are included. Patients with the AB investigation strain are shown in red (invasive sites) and orange (less-invasive sites); patients with an *A. baumannii* resistant to meropenem, but sensitive to some other antibiotics tested are labelled in green; and patients with an *A. baumannii* sensitive to most antibiotics, is shown in dark blue (invasive sites) and light blue (less invasive sites). The NICU ward is dominated by the AB investigation strain, while the PICU and CHW (data not shown) are dominated by sensitive *A. baumannii* strain(s).

Table 1 – Specimens positive for *A. baumannii* investigation strain by case patient

Date of birth (DoB), date of admission (DoA), date of first positive specimen (DoFPS), ward, and type and number of specimen collected from the 34 case-patients, December 2016-July 2017. The type of the first positive specimen is marked in yellow, and in the case of multiple positive specimen on the first day, all are indicated for that patient. Samples subjected to whole genome sequencing (WGS) are marked in bold red text (patient NV had a blood samples sent for WGS, but this strain was a sensitive strain and therefore not included in the table).

Case ID	Ward	Date of birth	Date of admission	Date of first positive specimen	MLST Type	Group	Blood culture	Chest drain	CSF	Urine	Central venous catheter tip	Endotracheal tube tip/ aspirate	Long line tip	Oro-gastric tube	Peritoneal drain	Pus swab	Rectal swab	Umbilical catheter tip	Total
1	NICU	03-Dec-16	03-Dec-16	13-Dec-16	2	1	**1**					3							4
2	NICU	16-Dec-16	16-Dec-16	26-Dec-16	NT					1		1							2
3	NICU	29-Dec-16	30-Dec-16	09-Jan-17	NT			1		1		1							3
4	NICU	04-Jan-17	04-Jan-17	13-Feb-17	2	1			**1**										1
5	NICU	03-Jan-17	04-Jan-17	10-Jan-17	NT								1						1
6	NICU	07-Feb-17	07-Feb-17	15-Feb-17	NT							1							1
7	NICU	12-Feb-17	12-Feb-17	15-Feb-17	2	1	**1**		**1**			1	1						4
8	NICU	18-Feb-17	18-Feb-17	23-Feb-17	2	1			**1**			1						1	3
9	NICU	20-Feb-17	20-Feb-17	23-Feb-17	2	1	**1**		**1**			1	1						4
10	NICU	21-Feb-17	22-Feb-17	24-Feb-17	NT							1						1	2
11	NICU	25-Feb-17	25-Feb-17	26-Feb-17	2	1	**1**										1		2
12	NICU	07-Mar-17	11-Mar-17	15-Mar-17	NT					1		3		1			1		6
13	NICU	15-Mar-17	15-Mar-17	16-Mar-17	NT							1							1
14	NICU	27-Mar-17	28-Mar-17	02-Apr-17	NT							1							1
15	NICU	16-May-17	16-May-17	24-May-17	NT					1		1							2
16	NICU	25-May-17	25-May-17	27-May-17	2	2	**1**		**1**			2						1	5
17	NICU	26-May-17	26-May-17	30-May-17	NT							1						1	2
18	NICU	28-May-17	28-May-17	01-Jun-17	NT							1							1
19	NICU	29-May-17	29-May-17	02-Jun-17	2	2	**1**					1							2

Case ID	Ward	Date of birth	Date of admission	Date of first positive specimen	MLST Type	Group	Blood culture	Chest drain	CSF	Urine	Central venous catheter tip	Endotracheal tube tip/ aspirate	Long line tip	Oro-gastric tube	Peritoneal drain	Pus swab	Rectal swab	Umbilical catheter tip	Total
20	NICU	04-Jun-17	04-Jun-17	20-Jun-17	NT								1						1
21	NICU	07-Jun-17	07-Jun-17	12-Jun-17	2	2	1					2							3
22	NICU	08-Jun-17	08-Jun-17	09-Jun-17	2	2	1	1											2
23	NICU	08-Jun-17	08-Jun-17	08-Jun-17	NT							1							1
24	NICU	09-Jun-17	09-Jun-17	25-Jun-17	NT							1							1
25	NICU	13-Jun-17	13-Jun-17	21-Jun-17	NT					1		1	1						3
26	NICU	14-Jun-17	14-Jun-17	20-Jun-17	NT					1		1						1	3
27	NICU	16-Jun-17	17-Jun-17	21-Jun-17	NT							1							1
28	NICU	22-Jun-17	22-Jun-17	23-Jun-17	2	2	1					1							2
29	NICU	23-Jun-17	24-Jun-17	01-Jul-17	NT							1							1
30*	NICU	17-Jul-17	17-Jul-17	21-Jul-17	NT		1												1
31	NICU	18-Jul-17	18-Jul-17	20-Jul-17	NT		1		2										3
32	PICU	18-Dec-15	19-Nov-16	08-Dec-16	NT										1				1
33	PICU	23-Jul-06	03-May-17	06-May-17	NT							1							1
34*	PICU	01-May-15	14-May-17	20-Jun-17	NT		1				1					1			3
Total							**12**	**2**	**7**	**6**	**1**	**29**	**5**	**1**	**1**	**1**	**2**	**5**	**74**

MLST: Multilocus sequence typing

NT: Not tested

CSF: Cerebrospinal fluid

*Two patients (Cases 30 and 34) were still admitted at the conclusion of the investigation.

Table 2 - Admission timeline of patients by week, 3 December 2016 – 31 July 2017

Invasive cases are shown in red; less-invasive cases are shown in orange. “X” indicates the first AB investigation strain positive specimen.

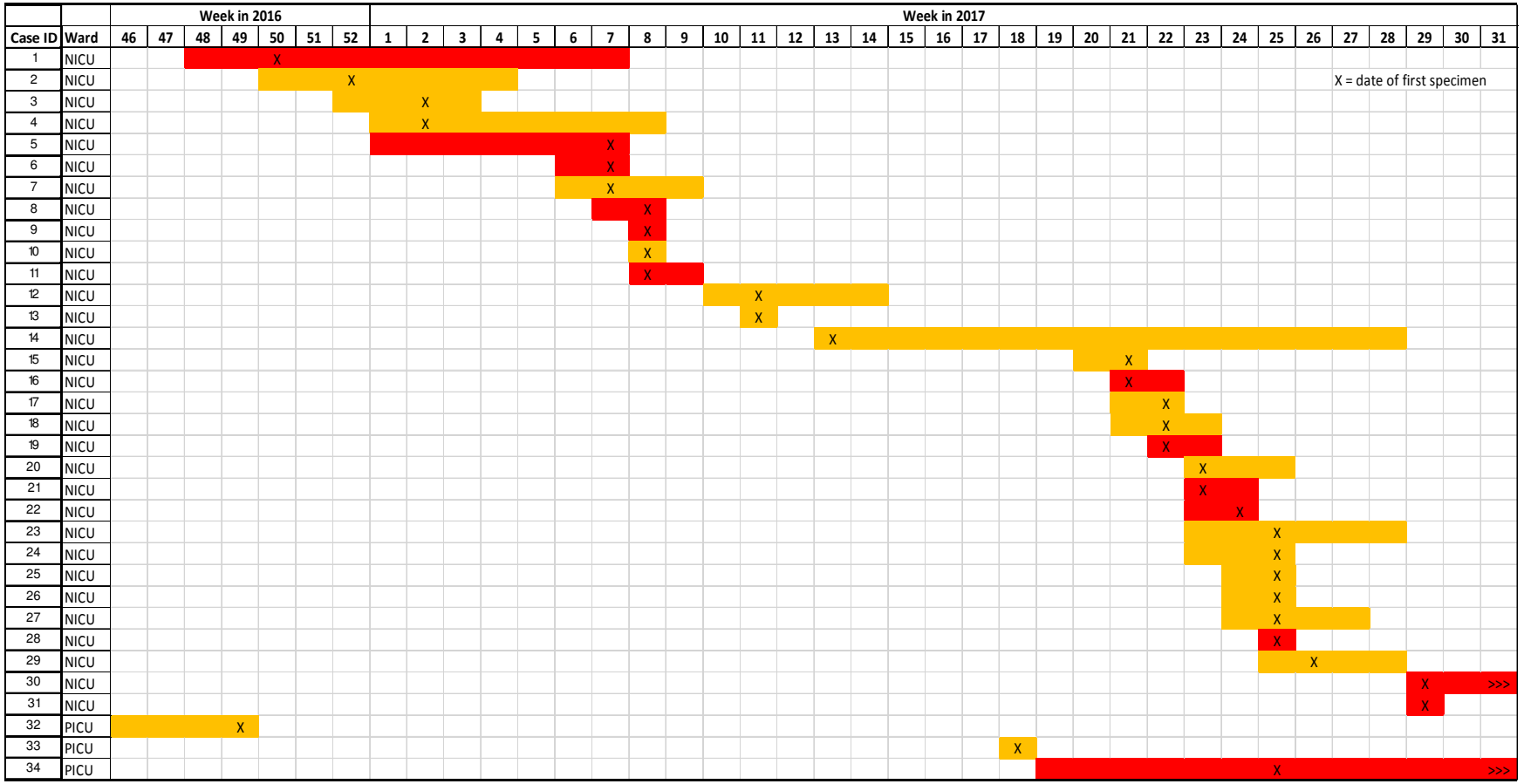
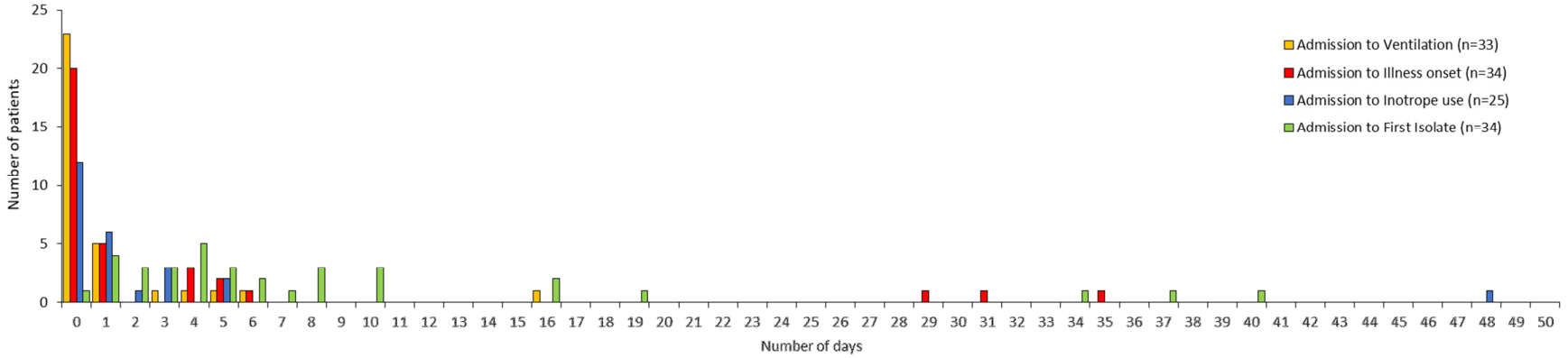


Figure 2 - Length of stay from admission to ventilation, illness onset, inotrope use and first AB investigation strain positive specimen for case-patients



4.1.3 Epidemiological description of the cases

The frequency of specific epidemiological characteristics for invasive and less-invasive cases can be found in **Table 3**. Only one of the invasive case-patients and two of the less-invasive case-patients were older than 2 months of age and were admitted to the PICU; all others were admitted to the NICU.

Ten (71%) of invasive cases and 19 (95%) less-invasive cases were iTaukei. Most of the invasive (8, 57%) and non-invasive (14, 70%) cases had a respiratory diagnosis as the reason for admission to the ICU. All 14 of the invasive cases (100%) and all but one of the non-invasive cases (19, 95%) had mechanical ventilation prior to the positive specimen being collected. These frequencies were reported to be much higher than estimates by paediatricians, stating that 60% of NICU and 40% of PICU require mechanical ventilation. Positive-pressure ventilation within 24 hours of admission was very common for invasive (13, 93%) and non-invasive cases (16, 80%).

Central lines were also common, especially among the invasive cases. While blood transfusions can also be common among PICU/NICU patients, all 14 invasive cases had a blood transfusion prior to the first positive specimen, as did many of the less-invasive cases (14, 70%).

Case-patients with recent births (<2 months old), were delivered by both caesarean section and vaginal delivery. Only one invasive case and one less-invasive case were delivered outside of CWMH, both of whom had a specimen negative for AB investigation strain on admission.

The gestational age of the neonatal case-patients at delivery varied, but only 2 (15%) invasive cases and 3 (17%) less-invasive cases were considered very preterm. Similarly, while the birthweights of the neonates at delivery varied, 13 (72%) of less-invasive cases were normal birthweight, while 3 (23%) invasive cases were normal birthweight.

While it was uncommon for cases to be very preterm or very low birth weight, case patients often had other medical problems resulting in their admission to the NICU. Most cases did not have other known risk factors for infection such as premature rupture of membranes (PROM) or meconium aspiration.

As shown in Table 3, endotracheal tube tips were the most common specimen type positive for the AB investigation strain in both invasive (8, 57%) and less-invasive cases (17, 85%). Twelve (86%) invasive cases had multiple positive samples, but this was uncommon for less-invasive cases (7, 35%). It was infrequent for invasive case-patients (3, 21%) and less-invasive case-patients (3, 15%) to have their first specimens positive for the AB investigation strain collected within a day of ICU admission, and even fewer patients had a positive specimen from the date of admission.

Table 3 - Demographic and clinical characteristics of the 34 case-patients, 1 December 2016 - 31 July 2017

Characteristics General characteristics	All case-patients n=34	Invasive case-patients[1] n=14	Less-invasive case-patients[2] n=20
Ethnicity			
iTaukei	29 (85%)	10 (71%)	19 (95%)
Fijians of Indian descent	5 (15%)	4 (29%)	1 (5%)
Age			
< 2 months	31 (91%)	13 (93%)	18 (90%)
2 months to <6 months	0 (0%)	0 (0%)	0 (0%)
6 months to <1 year	1 (3%)	0 (0%)	1 (5%)
>1 year	2 (6%)	1 (7%)	1 (5%)
Ward			
NICU	31 (91%)	13 (93%)	18 (90%)
PICU	3 (9%)	1 (7%)	2 (10%)
Microbiology Results			
Specimen type			
Blood	12 (35%)	12 (88%)	N/A[2]
CSF	6 (18%)	6 (43%)	N/A[2]
ETT	25 (74%)	8 (57%)	17 (85%)
First cultures collected positive for AB investigation strain	3 (9%)	0 (0%)	3 (15%)
First AB positive specimen collected on day of ICU admission	2 (6%)	0 (0%)	2 (10%)
First AB positive specimen collected within one day of ICU admission	6 (18%)	3 (21%)	3 (15%)
Multiple specimen positive for AB investigation strain	19 (56%)	12 (86%)	7 (35%)
Admission diagnoses			
Respiratory	22 (65%)	8 (57%)	14 (70%)
Birth defect	4 (12%)	1 (7%)	3 (15%)
Risk factors/Exposures			
Ventilation before positive culture	33 (97%)	14 (100%)	19 (95%)
PPV/ventilation within 24 hours of admission	29 (85%)	13 (93%)	16 (80%)
Central line before culture positive	27 (79%)	13 (93%)	14 (70%)
IV phlebitis before culture positive	4 (12%)	1 (7%)	3 (15%)
Inotropes	22 (65%)	9 (64%)	13 (65%)
TPN before culture positive	8 (24%)	4 (29%)	4 (20%)
Blood transfusion before culture positive	28 (82%)	14 (100%)	14 (70%)
Treatment			
Treated with meropenem	23 (68%)	11 (79%)	12 (60%)
Initiation of meropenem during last day of life	5 (15%)	4 (29%)	1 (5%)
Treated with colistin	12 (35%)	7 (50%)	5 (25%)
Initiation of colistin during last day of life	3 (9%)	2 (14%)	1 (5%)
Outcomes			
Death	23 (68%)	12 (86%)	11 (55%)

Characteristics	All case-patients	Invasive case-patients[1]	Less-invasive case-patients[2]
Perinatal characteristics	**n=31**	**n=13**	**n=18**
Delivery type			
Caesarian section	12 (39%)	4 (31%)	8 (44%)
Vaginal delivery	19 (61%)	9 (69%)	10 (56%)
Delivery location			
CWM	29 (94%)	12 (92%)	17 (94%)
Outside hospital	1 (3%)	1 (8%)	0 (0%)
Home	1 (3%)	0 (0%)	1 (6%)
Gestational age			
Term	15 (48%)	4 (31%)	11 (61%)
Mod-late preterm	11 (35%)	7 (54%)	4 (22%)
Very preterm	5 (16%)	2 (15%)	3 (17%)
Birthweight			
Normal	16 (52%)	3 (23%)	13 (72%)
LBW	7 (23%)	5 (38%)	2 (11%)
VLBW	8 (26%)	5 (38%)	3 (17%)
Meconium in amniotic fluid on delivery	11 (35%)	4 (31%)	7 (39%)
Concern for meconium aspiration	7 (23%)	3 (23%)	4 (22%)
Premature ruptures of membranes (PROM)	7 (23%)	4 (31%)	3 (17%)

[1] Blood or CSF specimen; [2] Specimen(s) other than blood or CSF only

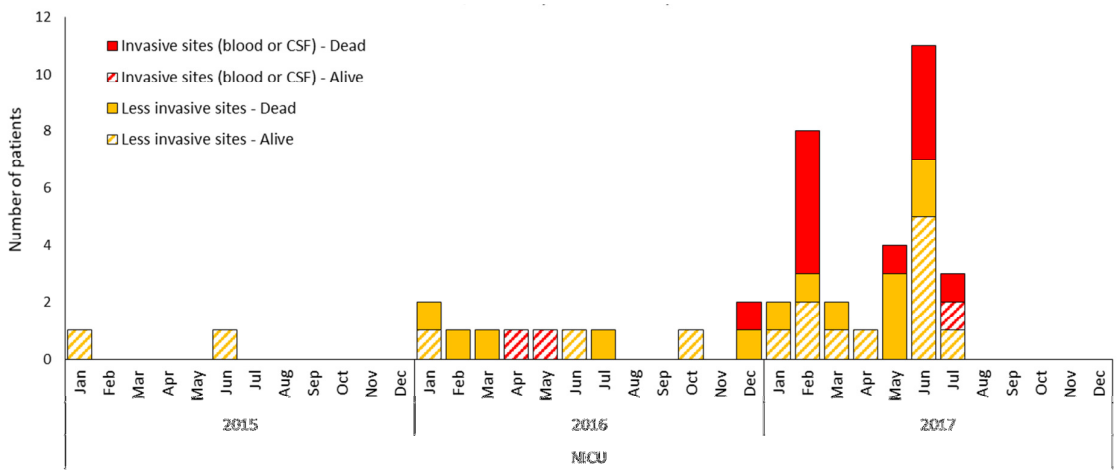
The median time from admission to onset of illness was 0 days (range 0-35 days), with 59% of patients having onset of illness on the day of admission, as shown in Figure 2. However, the illness onset is not necessarily attributable to an *A. baumannii* infection and may reflect illness due to the patients' other medical conditions. Of the 25 patients requiring inotropes, the median length of time from admission to initiation of inotrope was 1 day (range 0-48 days). Inotropes were initiated on the day of NICU admission for 48% of these patients.

The median time between admission and the first positive *A. baumannii* specimen was 5 days (range 0-40 days), with 65% of patients having a positive isolate within the first week. All but one of the case-patients required ventilation during their admission, with a median of 0 days (range 0-16 days), and 70% of patients ventilated on the day of admission.

As seen in Table 3, eleven (79%) invasive cases and 12 (6%) less-invasive cases were treated with Meropenem, but treatment with Colistin was less common (7 [50%] invasive cases; 5 [25%] less-invasive cases). However, this does not reflect the appropriateness of antibiotic treatment or that several patients had the first positive samples collected by clinicians after death.

The case fatality rate among invasive cases was 86% (12 of 14 invasive case-patients) at the conclusion of the investigation, while death was less common among non-invasive cases (11 of 20 non-invasive case-patients, 55%). This is illustrated in **Figure 3**, which also includes patients admitted to the NICU before the outbreak. From this figure, it appears that there has been a sharp increase in both number of patients, and deaths of patients, with the AB investigation strain.

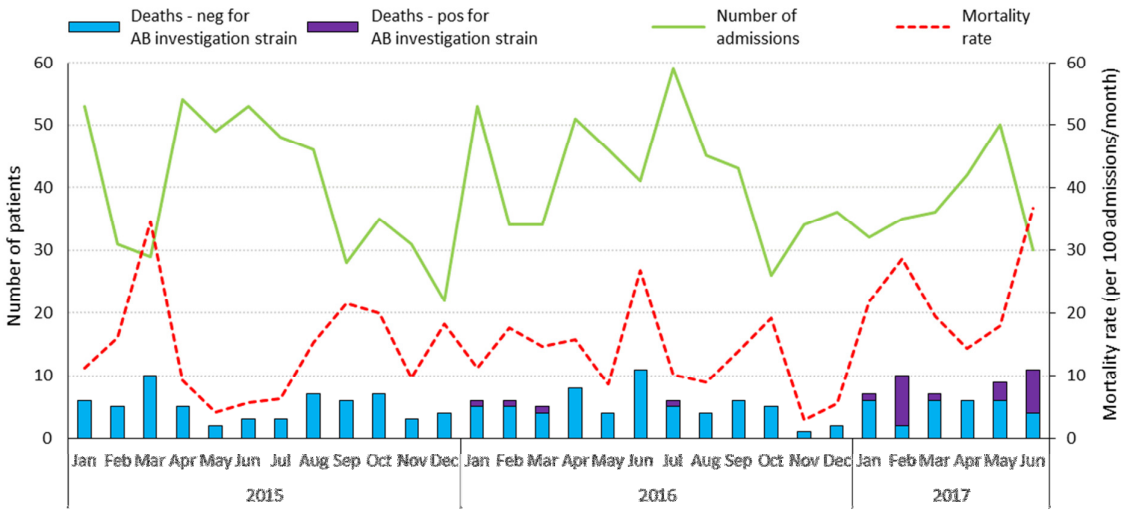
Figure 3 - Outcomes for NICU patients with the AB investigation strain isolated from invasive and less invasive sites, 1 January 2015 – 31 July 2017)



Patients who died are marked in solid bars, and patients who survived are marked with hashed bars. Only one positive specimen (the most invasive) is shown for each patient; red: invasive site; yellow: less-invasive site. Along with an increase in AB investigation strain positive specimens from invasive sites, there has been an increase in the number of deaths with positive specimens.

Although **Figure 4** shows that overall number of neonatal deaths in the NICU varied over time, the data suggests an increase in the proportion of patients positive for the *A. baumannii* investigation strain among those who died in 2017. The overall mortality rate increased from 1 December 2016 to 30 June 2017, with peaks occurring at the same time as the two clusters of invasive cases. The June 2017 mortality rate is at the highest level over the 30 month period since 1 January 2015.

Figure 4 – NICU admissions, number of deaths with and without the AB investigation strain and mortality rate per 100 NICU admissions, 1 January 2015 – 30 June 2017



While this investigation focused on the NICU because of high numbers of cases from the NICU, there were three PICU cases (two invasive cases and one less-invasive case) included in the analysis because they occurred during the same time as the NICU cases and may be epidemiologically related as some exposures (such as equipment) can be shared between these units. These PICU patients had unique hospital courses and exposures, often different than those of the neonates in the NICU. Two PICU cases had severe chronic medical problems and had a specimen positive for the AB investigation strain after long hospital stays (2-4 weeks). The other PICU case was transferred in a critical condition from an outside hospital and had a specimen positive for the AB investigation strain and a sensitive strain several days after admission. Of note, there is also an anecdotal report that one of these patients was mechanically ventilated on a ventilator borrowed from the NICU.

4.1.4 Environmental sampling

Environmental samples tested by CWMH were negative for *A. baumannii*; specific results can be found below.

Table 4 - Results of environmental sampling

Environmental sample location	Culture result
Hand hygiene sink	Negative
Ventilator	Negative
TPN	Corynebacterium (repeat culture was negative)
Distilled water from dental clinic	Pseudomonas aeruginosa (repeat culture was negative)

4.1.5 Whole genome sequencing

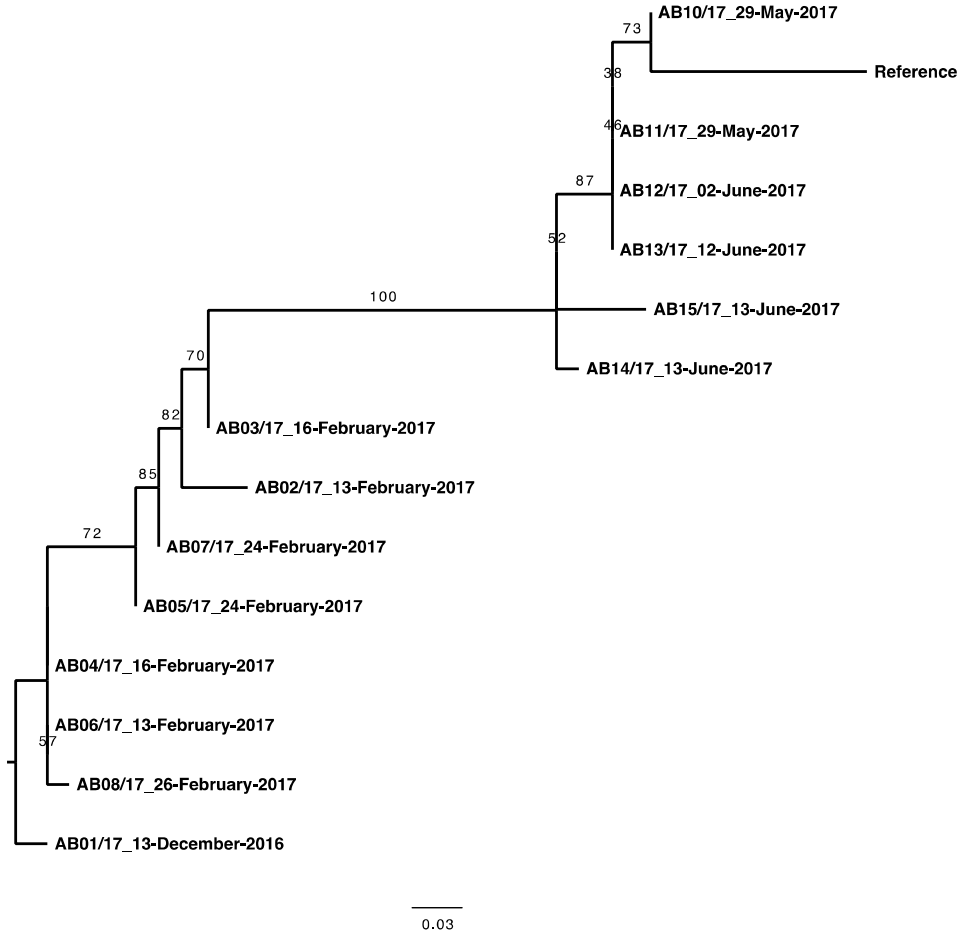
Nine (9) blood culture isolates and 5 cerebrospinal fluid isolates were sent to the Microbiological Diagnostic Unit Public Health Laboratory, University of Melbourne (MDU-PHL), for whole genome sequencing, with 3 patients having samples from both sites sent for testing. *In silico* multilocus sequence typing of the isolates showed 14 belonging to sequence type 2 (ST2) and one isolate belonging to ST107.

Upon review of the original microbiology results, it was discovered that the blood culture sample for the patient with ST107 grew a non-investigation strain of AB which was sensitive to Meropenem, while another longline tip sample from this patient grew the AB investigation strain.

All other samples sent for analysis grew the AB investigation strain. All the ST2 isolates contained the plasmid-mediated carbapenemase gene $bla_{\text{OXA-23}}$, and all but one contained the 16S rRNA methyltransferase gene *armA* (conferring high-level aminoglycoside resistance). This is a commonly observed clone internationally. [4-10]

For the ST2 isolates the MDU-PHL used genome wide single nucleotide variants, with recombinant sites removed, to reconstruct the phylogenetic relationship between all the samples. The resulting phylogenetic tree is presented in **Figure 5**. The analysis shows that the ST2 isolates form two groups of isolates. Group 1 is composed of isolates from the first cluster and group 2 is composed of isolates from the second cluster, and the results suggest that group 2 evolved from group 1. The nucleotide variations accumulated over the three months between the two clusters suggest that the strain is capable of evolving reasonably rapidly.

Figure 5 - Maximum-likelihood tree inferred from recombination-free alignment



Bootstrap support values are shown on each branch. Tips are labelled with the reference number and date of isolate. The tree was rooted using the oldest isolate in the collection.

4.2 INFECTION PREVENTION AND CONTROL EVALUATION

Utilising the tool described in the methods section, facility wide IPC evaluations were conducted in collaboration with the ICC and other IPC staff of each facility, with evaluation scores shown in **Table 5**. The results indicate an inability to provide evidence based IPC practice for the delivery of safe and effective care, putting staff in a position of "making do" or "improvising" in the absence of adequate supplies. For example, the lack of disposable, single-patient-use equipment, leads to reprocessing of equipment that cannot be effectively decontaminated, such as nasal prongs and other respiratory equipment which is implicated in similar outbreaks.

Table 5 - Results of Infection Prevention and Control Evaluations, July 2017 (each completed tool attached, Annexes 4-6)

Attribute assessed	Lautoka %	Labasa %	CWMH %
Organisation	71.4	100	57.1
Epidemiological surveillance of infections	41.2	41.2	35.3
Microbiology	83.3	58.3	75
Intervention strategies	56.4	81.6	44.3
Sterilisation and high-level disinfection	63.6	45.5	45.5
Personnel health	42.9	57.1	42.9
Hospital environment and sanitation	76.8	73.6	60.6
Total	**62.2**	**65.3**	**51.5**

Compliant: 85% or above
Partial compliance: 76-84%
Minimal compliance: 75% or below

Specific IPC issues for ALL facilities:

- Inconsistent use of contact precautions and decontamination protocols in the NICU (and all high-risk units)
- Poor hand hygiene compliance
- Inadequate isolation facilities
- Inconsistent use of personal protective equipment
- Inconsistent identification and use of transmission based precautions
- Reprocessing single use items respiratory equipment
- Inadequate cleaning of equipment between patients
- Decanting of solutions into inappropriate vessels (without appropriate decontamination)
- Multi-access of sterile solutions (IV medications and IV solutions)
- Poor IV therapy administration and practices
- Inappropriate antiseptic and disinfectant agents
- Unsafe disposal of sharps
- Inability to verify sterility of equipment and consumables processed by hospital sterile services
- Lack of planned maintenance for all equipment
- Overcrowding

Completed IPCP evaluation audit findings are presented in **Annexes 3-5**, for each hospital respectively. Each facility received feedback at the end of each evaluation, and reviews were conducted with the relevant IPC teams, with peer-to-peer teaching performed throughout.

4.3 PREVIOUS MDRO OUTBREAK INVESTIGATIONS

It is important to note that CWMH has had at least 10 MDRO outbreaks documented since 2006 caused by various organisms including *A. baumannii*, *K. pneumoniae*, *Enterobacter aerogenes*, *Serratia marcescens*. Investigations of these outbreaks (including those by previous WHO consultants) resulted in very similar findings and recommendations as this investigation, including poor IPC practices, many of which result from inadequate and inconsistent supply of consumables and equipment. This has led to the perpetuation of poor IPC practices (including hand hygiene,

standard and transmission based precautions, safe injecting practices, and aseptic technique) based on a concern for the availability of supplies. This ultimately impacts upon patient safety and enables the transmission of healthcare associated infections.

5. DISCUSSION

There have been clinical specimen positive for the AB investigation strain from CWMH NICU patients as early as January 2015, with several sporadic cases detected from January to November 2016 However, since December 2016 there has been an increase in both invasive and less-invasive cases and an increase in mortality among these patients.

While many patients in the current outbreak had illness onset on the day of admission or the day after admission to a paediatric ICU at CWMH, the first specimen taken following ICU admission was negative for *A. baumannii* for most cases, suggesting that these patients were likely not colonized or infected on admission. Even though it is possible that transmission could occur at delivery prior to NICU admission, the lack of early positive specimens and the variety of delivery locations (labour ward for vaginal deliveries and the operating theatre for caesarean sections) suggests that transmission was occurring within the NICU due to persistent contamination of the NICU environment.

Because clinical management is often similar for all NICU patients, it can be difficult to identify a common exposure unique to the cases that are part of a cluster. Invasive devices such as mechanical ventilation and central lines are common practice for all neonates requiring admission to the NICU, but information about specific exposures of each case-patient (such as the exact ventilator device) used was not documented to compare exposures of individual case-patients in more detail.

It is possible that the source of *A. baumannii* within the NICU is multifocal (i.e. multiple contaminated surfaces or equipment). Considering that this bacterium can survive on surfaces for extended periods of time and in biofilms, the infection control assessment identified multiple issues in IPC that could have resulted in cross-contamination, including lack of appropriate cleaning of the patient environment and equipment as well as lack of appropriate transmission-based precautions. Previous outbreak experience with this organism has demonstrated that frequently multiple sources are contaminated in the hospital environment [11-26], with eradication typically needing a thorough, comprehensive approach to cleaning and disinfection of patient care equipment as well as ensuring appropriate compliance with hand hygiene and contact precautions.

While multiple sources of transmission are likely, the high frequency of positive pressure ventilation within 24 hours of birth, the high frequency of mechanical ventilation prior to a positive specimen, and the high frequency of positive specimens from ETT tubes may suggest a respiratory source of transmission such as shared ventilators or respiratory equipment inadequately cleaned between patients. This concern is further highlighted by the lack of single-use disposable respiratory equipment and inadequate cleaning of shared respiratory equipment found during the infection control assessment. While the PICU case-patients may have not shared the same environment, they may have been exposed to the same contaminated equipment as NICU cases, including a NICU ventilator for one of the PICU case-patients. This theory is supported by genomic testing results demonstrating that all invasive cases had a single strain and it is highly likely that the same strain would also be found in specimens from less-invasive sites if they had been tested.

While the high mortality of cases is alarming, it is difficult to determine the contribution of the *A. baumannii* in the deaths of these patients, especially because not all deaths were attributed to the *A. baumannii* infection in the medical chart. Nevertheless, the bacteria likely put an added burden on an already fragile and sensitive patient population and are dangerous in an intensive care environment. Once the IPC, infrastructure, and medical supply chain issues are resolved, it is expected that HAI transmission will be markedly reduced.

Many of the infection control gaps identified were associated with a lack of consistent equipment and consumables present in all three health facilities evaluated, preventing the appropriate implementation of IPC practices. Based on the evidence provided by each of the IPC teams and committees, supply staff, and clinicians, these deficiencies appear systemic.

While it is impossible to identify a specific point source for this outbreak, the wide variety of poor IPC practices suggest that all IPC issues should be addressed to improve patient safety. The greatest concerns for this specific outbreak are:

1. The reuse and reprocessing of single patient use respiratory equipment
2. The lack of consistent availability of hand hygiene equipment and IPC consumables
3. The use of IV solutions and medications for longer than 24 hours after first access, and multi-access for multiple patients
4. The lack of effective cleaning of patient care equipment between patients
5. Inadequate application of standard and transmission based precautions, particularly contact precautions

6. LIMITATIONS OF THE STUDY

Due to the manual nature of medical charts, logs, and other surveillance systems, the documentation needed for a more comprehensive investigation was not consistently available for all patients. The GOARN team encountered several occasions where important data, such as microbiology laboratory results or the medication administration record, were missing from the patient charts.

Occasionally, there were inconsistencies in the data from different data sources, including microbiology results from one data source which may have been different or not present in another data source. For example, while the neonatal deaths registry did not consistently include microbiology results it did include three patients in 2016 with *A. baumannii* from an invasive body site; these cases were not documented in the MRO log and did not have AST data included. These patients were discovered late in the investigation, and there was insufficient time to locate and examine the patient charts.

Only limited information on the mothers of the case-patients was available as the medical charts for most of the mothers were not located; it is therefore not possible to assess exposures related to the mother's experience during pregnancy or at delivery.

Because clinical management is very similar for all NICU patients, without a case-control study it can be difficult to identify exposures unique to the cases, or a common exposure to all patients, which may be important in transmission of the AB investigation strain.

There was also insufficient time to conduct an observational study of practices and procedures within the NICU, following patients from the time of admission to final outcome (discharge or death), which could provide a more detailed understanding of specific risk factors associated with policies and practices in the unit and individual critical control points for intervention.

Since all the sequence type 2 isolates had the same AST profile (resistant to all antibiotics used at CWMH), this finding was extrapolated to suggest that all isolates with this AST profile belonged to the ST2 lineage. This is highly probable, but cannot be proven without performing whole genome sequencing. Whole genome sequencing of a wider selection of samples, including some from less invasive sites, would be needed to confirm whether one or more clones of MDRAB were present in the NICU from December 2016 to July 2017. However, any additional sequencing results would not alter the recommendations for outbreak control and IPC strengthening.

7. ACTIONS AND RECOMMENDATIONS

7.1 IMMEDIATE ACTIONS TAKEN

Based on concerns about ongoing transmission, some targeted measures were taken immediately to prevent further transmission.

- On-site training and assistance was provided on implementing effective contact precautions in the NICU for neonates with a specimen positive for an MDRO (especially resistant *Acinetobacter baumannii)*, including dedicating equipment to these patients to reduce shared equipment, improving appropriate hand hygiene and glove use for contact with these patients and their environment, maximizing space between patients, and daily education for NICU staff.
- On-site training and assistance was also provided on effective cleaning of the environment and patient equipment, including guidance for cleaning with the cleaning agents currently available as well as supporting the MOHMS in the emergency procurement of certain essential single-use, disposable equipment.
- Investigation findings were shared with administrators, clinicians, and staff from the MOHMS and CWMH to inform the immediate changes above.

Processes to improve IPC implementation in the NICU were established for CWMH staff to continue (see **Annex 7**, CWMH Workplan), including:

- Development of an ongoing IPC education or training program for all staff including non-clinical cleaning staff and visitors, focusing first on staff working in the NICU and then expanding to other wards. This includes a plan for orienting visitors about important IPC practices (especially hand hygiene and contact precautions) where compliance is low and may include visual aids and a monitoring system for tracking staff and visitor training. This may also include a simulation component for staff to demonstrate competency in these IPC practices (i.e. having staff demonstrate how they would care for a neonate on contact precautions or how they would clean equipment).
- Development of a system to monitor compliance with IPC practices. While hand hygiene audits are conducted by the infection control team, this information may not be effectively communicated back to the frontline staff and used to inform improvement initiatives. In addition to hand hygiene, it may also be beneficial to conduct audits or monitor indicators of other infection control practices, such as contact precautions or cleaning/disinfection.

Monitoring compliance of these activities may be complicated, but can be accomplished by choosing specific, measurable actions to audit (such as use of gloves when contacting a neonate and their environment or disinfection of equipment for patients on contact precautions (including stethoscope) and by developing tools (such as an audit tool for contact precautions or daily cleaning checklist to ensure regular cleaning of each patient environment).

- Education on IPC for patients and families who come into contact with the health facility should be available and accessible;
- Development of patient feedback system for patients to express their concerns related to IPC.

7.2 RECOMMENDATIONS

Given the recent cases and the concern of ongoing transmission for many months, CWMH will need to devote significant resources for tracking and stopping this outbreak. First, it is recommended that CWMH continue ongoing surveillance for resistant *Acinetobacter baumannii,* focusing on high risk areas such as ICUs. If future cases (invasive and/or less-invasive) occur, documentation of patient location within a unit and documentation of specific equipment used for these patients (e.g. which ventilator) will be helpful to identify possible common sources of transmission.

Continued screening for *A. baumannii* may not be beneficial for outbreak control for a few reasons. First, it is likely that the source of *A. baumannii* is within the NICU; screening for MDROs is typically employed to prevent these organisms from gaining entry to a vulnerable patient population. Second, there is no consensus method for screening patients for carriage of *A. baumannii* and the sensitivity of surveillance cultures is low even when multiple body sites are sampled. Therefore, regular screening cultures to identify carriage or colonization may not be cost-effective, and resources are likely better spent on infection control prevention activities.

Additional support for "destructive sampling" has been offered via Dr Karen Vickery of Macquarie University in NSW, Australia. Destructive sampling involves items being destroyed to detect pathogens in biofilms, so any items considered for this form of testing would have to be replaced. Given the plethora of IPC practice issues that require rectification at this time, and these recommendations have been made since 2007 via various outbreak investigation reports, such sampling does not appear to be of priority at this time.

Based on the epidemiological investigation and infection control assessments, recommendations and a related action plan were drafted (included below) and shared with MOHMS and hospital leadership to identify and ensure implementation of important short, medium, and long-term actions aimed at:

- Improving IPC practices, including appropriate hand hygiene, transmission-based precautions (especially contact precautions), use of sterile medications/solutions for injections
- Improving cleaning of patient care environment and equipment, including avoiding reuse of single-use, disposable equipment and ensuring effective sterilization of items
- Effectively implementing the Infection Control Committee, including improving technical capacity of IPC team, implementing targeted healthcare-associated infection surveillance, conducting staff training on IPC, developing a IPC nurse liaison program. All activities to be overseen by the IPC Committee, in which leadership is included according to the Terms of Reference) and the hospital's risk management/clinical governance structure and used to make management and policy decisions

- Developing standardized regional, national, and facility guidance, policies, or standard operating procedures (SOPs) on IPC.

Many of the short-term activities will focus on the high-risk areas such as ICUs initially but will then be applied to other patient care areas. There are multiple challenges in effectively implementing these activities which will require actions from multiple responsible parties during a timeframe outlined in the action plan, including knowledge and training, supplies and resources, effective oversight and monitoring systems. The MOHMS and hospital leadership voiced commitment to following this action plan and meeting regularly to assess progress and obstacles to implementation.

Finally, in order to effect sustainable improvements in IPC practices, there is a need for a longer term health systems approach to the problems identified in order to reduce likelihood and impact of MDRO outbreaks.

7.2.1 Proposed action plan for hospital infection prevention and control

All IPC principles, practices, and guidelines should be in line with recognised standards, evidence-based principles and accepted best practices, but this is not achievable due to the nature of the current context and resource limitations. However, there are key recommendations to be implemented **FOR ALL FIJI HEALTH FACILITIES** (unless otherwise noted) on a short, medium and long-term basis which have been discussed and agreed upon by stakeholders. This action plan includes specific activities, the target group for implementation, responsible persons, and the timeframe for completion. WPRO has suggested organizing these recommendations into health system areas, rather than in order of priority (included in appendix). These recommendations include aspects OTHER than IPC needs (Annexe 8).

Short term plan (14 days) as of 26 July 2017				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
Cease reprocessing of all respiratory equipment in all high-risk units. Respiratory equipment should be single patient use and disposed of after patient discharge	All ICUs Burns Unit Operating Theatre (OT)	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		Decision to be made whether to purchase single-use disposable equipment, or reusable equipment that can effectively be cleaned	Medical Superintendent	Completed within 1 month
		Ensure reliable supply of respiratory equipment (whichever option is chosen above)	FPBS Hospital supply staff	Continuous
		Ambu bags and masks MUST be either discarded or thoroughly cleaned and disinfected between patients with NEW oxygen tubing – follow SOP from IPC team on cleaning of the NICU environment for all high-risk areas	Staff of all ICUs and OT	Effective immediately and continuous
Hand hygiene compliance must be improved, with initial focus on high risk units and then to other departments.	All ICUs Burns Unit All wards (longer term)	Ensure implementation and adherence, through reports from IPC Committee	Medical Superintendent	Effective immediately and continuous
		Adequate and consistent provision of hand hygiene supplies (70% alcohol hand rub at each ICU bed, liquid soap and paper towel at each hand basin)	FPBS Hospital supply staff	Continuous
		Hand hygiene training, focusing on the 5 moments	ICC	Effective immediately

Short term plan (14 days) as of 26 July 2017				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
		of hand hygiene to be conducted		and continuous
		30 moments a week auditing for a month (use HHA tool) and then collect 30 moments per month. Set a hand hygiene compliance goal of 80% facility wide. Feedback at time of audit and weekly/monthly feedback to relevant department staff	IPC team	Effective immediately and continuous
All contact with patients in ICUs requires use of gloves and plastic disposable apron, to be changed and discarded between patients. Eye protection required at every ICU bed.	All ICUs Burns	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		Plastic disposable aprons, N95 masks, disposable gowns, eye protection are required to be added to the stock list	FPBS	Continuous
		All staff in ICUs should use gloves and plastic disposable aprons	IPC team	Effective immediately and continuous
For IV fluids, IV medications and dressing use, only use sterile solutions.	All ICUs Burns OT All wards (longer term)	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		Small volume normal saline required: 10mls, 100mls, 500mls	FPBS	Effective immediately and continuous
		Ensure adequate supply of IV medicines such that they do not have to be shared.	FPBS	Effective immediately and continuous
		Cease use of multi-access solutions for multiple patients. If necessary, solutions are dedicated to single patient use only and kept for a maximum of 24hrs – only if re-sealable	IPC team Staff of all ICUs	Effective immediately and continuous
IV giving sets must be replaced in 72hrs; IV fluids should be changed	All units	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous

Short term plan (14 days) as of 26 July 2017				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
every 24hrs		A consistent and adequate supply of IV consumables must be maintained	FPBS	Continuous
		If IV lines must be disconnected from patient, ensure sterility of line by adding a sterile bung or other IV component to the end of the line until next use	IPC team Staff of all units	Effective immediately and continuous
Improve cleaning of patient care environment and patient care equipment.	All units	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		All equipment must be cleaned with a neutral detergent between patients. In the current situation, use of 1% sodium hypochlorite after cleaning is advisable (ICUs). This is using disposable cloths, which ARE disposed of after each use	IPC team Staff in all units	Effective immediately and continuous
		All sticky residues to be removed from equipment.	Cleaning staff Staff in all units	Effective immediately and continuous
		Ensure curtain cleaning schedules (monthly) are performed	Cleaning staff	Effective immediately and continuous
Produce and use signage to indicate the need for transmission based precautions	All units	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		Produce and use signage to indicate the need for transmission based precautions	IPC team	Effective immediately and continuous
		Appropriate use of signage to be verified by IPC staff daily.	IPC team	Effective immediately and continuous
All high-risk units to receive training	All ICUs	Ensure implementation	Medical Superintendent	Effective immediately

Short term plan (14 days) as of 26 July 2017				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
from IPC team on new initiatives (see all above recommendations) for implementation and adoption in their units. This can then be rolled out to all other units.	Burns OT All wards (longer term)			and continuous
		Conduct the training	IPC team	Effective immediately and continuous
Specific to CWMH				
There is currently no capacity to ensure sterility of equipment being processed through the **ONE** operational autoclave at CWMH. Three autoclaves are currently inoperable	All units	A contingency plan for autoclave failure must be created.	Permanent Secretary Medical Superintendent	Effective immediately
		A plan for sourcing appropriate replacement autoclaves for the CSSD	Permanent Secretary Medical Superintendent	Effective immediately
Change sterilization practices of small items (swabs, gauze, etc.) to sterilization pouches which are heat sealed and autoclaved, instead of wrapping in butchers' paper which cannot maintain sterility	CSSD	Ensure implementation and adherence	Medical Superintendent	Effective immediately and continuous
		Ensure reliable supply of sterilization pouches	FPBS Hospital supply	Continuous
		Purchase heat sealers for the CSSD	Supply	Effective immediately
		Acquire chemical indicators to be placed inside wrapped packs for sterilization	FPBS CSSD	Completed within 1 month
Log book kept of autoclave loads	CSSD	Log book kept of autoclave loads (as per protocol at Lautoka)	CSSD Nursing Manager	Effective immediately and continuous

Medium term plans (1-3 months)				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
Consistent provision of equipment/consumables to support IPC practices by clinicians	All clinical areas	Ensure implementation	Medical Superintendent	Completed within 1 month
		Hand hygiene equipment/consumables throughout health facilities	FPBS Hospital supply	Continuous
		PPE – consistent supply	FPBS Hospital supply	Continuous
Monthly Infection Control Committee meetings (with minutes)	Infection Control Committee	Monthly Infection Control Committee meetings (with minutes). Activities and outcomes, monitoring and evaluation of all IPC activities	Infection Control Committee	Commenced within 1 month
Review of Terms of Reference and activities of ICC	Infection Control Committee	Updated TORs and activities, goal setting with roles and responsibilities identified	Infection Control Committee	Completed within 1 month
Purchase clippers for surgical site preparation.	Surgical units OT	Ensure implementation	Medical Superintendent	Completed within 1 month
		Purchase of clippers	Hospital supply	Completed within 1 month
		Ensure consistent and adequate supply of clippers	Hospital supply	Continuous
Targeted healthcare associated infection surveillance, to establish baseline data and allow trend analysis to detect deviations from the norm (e.g. outbreaks)	All units	Establish: • Standard operating procedures for the collection, analysis and reporting of data • Minimum data set • Focus on clinical, not environmental surveillance • Cease M/C/S of tips (IDC, NGT, ETT, OGT, CVC) – unless clinically indicated	Medical Superintendent IPC Committee	Completed within 3 months

Medium term plans (1-3 months)				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
		• Elective surgery only – LSCS and hernia repair (divided between superficial and deep incisional) • Central line associated blood stream infections (CLABSI) ICU • Catheter associated urinary tract infection (CAUTI) ICU MROs of significance: - Extended spectrum beta-lactamase (ESBL) producing organisms - Multi-resistant *Staphylococcus aureus* (MRSA) - Multi-resistant *Acinetobacter baumannii* (MDRAB)		
Implement Infection Control Link/Liaison Nurse Program. This will raise the profile of IPC in all units, allow for succession planning for IPC team, and build capacity and leadership of IPC team	All units	Ensure implementation	Medical Superintendent	Completed within 3 months
		Expressions of interest from ward staff (opinion leaders, leadership qualities)	IPC team	Completed within 1 month
		Training to include: • Shadow of IPC team members • Hand hygiene Australia modules – auditing process (freely available at http://www.hha.org.au/) • Australian Commission for Quality and Safety in Healthcare modules (freely available at http://infectionprevention.e3learning.com.au/) • Environmental auditing process	IPC team	Completed within 3 months

Medium term plans (1-3 months)				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
		Activities to include: • Hand hygiene audits • Environmental audits – cleaning, waste, sharps • Monthly education sessions with IPC team • Audit reports to IPC teams monthly		
Improve general cleaning capacity of the facilities, including training of cleaning staff in-line with the needs of the facility and for cleaners' safety	Cleaning staff		Medical Superintendent IPC team Cleaning staff	Completed within 1 month

Long term plan (>3 months)				
Area of action	**Target group**	**Individual components**	**Responsible persons**	**Timeframe**
Review and update of IPC Guidelines to include targeted surveillance activities	All HCWs	IPC Guidelines for the region and Fiji	MOHMS to liaise with WHO and SPC	Completed within 4 months
Review and update of IPC Policy for Fiji to include targeted surveillance activities and methodologies, IPC practices identified in short term and medium term goals	Fiji Health Services	New and updated policy to support IPC practice for Fiji.	Fiji MoH Policy Department All IPC Committees All IPC teams MOHMS	Completed within 4 months
Capacity and leadership building of IPC team through formal training of IPC staff	IPC staff	Develop a training plan	Permanent Secretary Medical Superintendents Donor agencies	Completed within 6 months
Review of and development of plan for improved sterilization practices for all health services	All health facilities	Quality assurance of sterility of equipment in Fiji	Permanent Secretary Medical Superintendents Donor agencies	Completed within 4 months
MoH IPC Clinical Services Network establishment	All IPC teams	Capacity and leadership building of IPC team	MOHMS All IPC Committees	Completed within 6 months
Seek external support to assist with IPC and CSSD capacity and development in Fiji, for 12 months (previous AusAID volunteer advertisement attempted unsuccessfully)	All health services	Capacity and leadership building of IPC team	Permanent Secretary Nursing Manager	

8. ANNEXES

1. Daily Mission Travel Schedule and Key Persons Met (P-A Zimmerman)
2. Daily Mission Travel Schedule and Key Persons Met (M. Lyman and P. Andersson)
3. Infection Prevention and Control Programme Evaluation tool
4. IPCP Evaluation Lautoka
5. IPCP Evaluation Labasa
6. IPCP Evaluation CWMH
7. CWMH Workplan
8. WPRO Additional recommendations as of the 1 August 2017
9. Presentation to the Permanent Secretary of Health 26 July 2017

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