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Carbapenem-Resistant *Acinetobacter Baumannii*

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World Health Organization

WHO Bacterial Priority Pathogens List, 2024

Bacterial pathogens of public health importance to guide research, development and strategies to prevent and control antimicrobial resistance

In this update, Gram-negative bacteria that are resistant to last-resort antibiotics, such as *Acinetobacter baumannii* and various pathogens in the Enterobacterales order, as well as rifampicin-resistant (RR) Mycobacterium tuberculosis, are listed as of critical priority because of their ability to transfer resistance genes, the severity of the infections and disease they cause and/or their significant global burden, particularly in LMIC.

WHO Bacterial Priority Pathogens List 2024

U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

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CDC's 2019 Antibiotic Resistance Threats Report

Why is *Acinetobacter baumannii* so relevant?

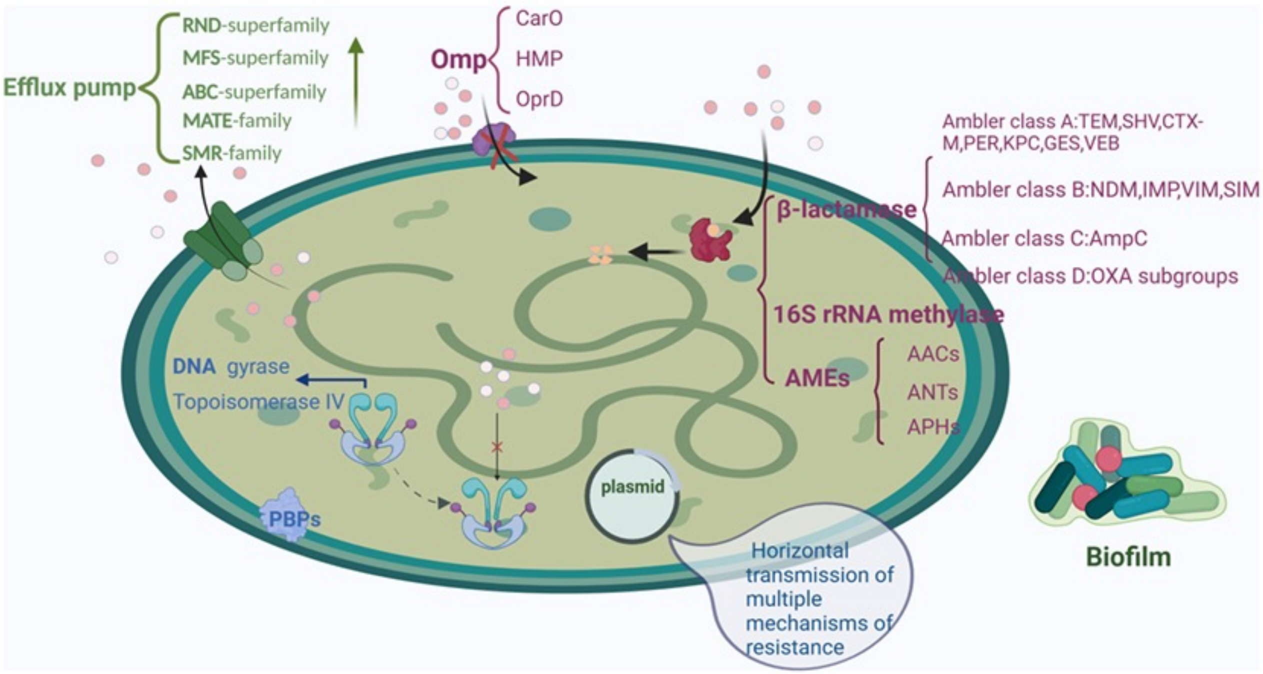

FIGURE 1
Mechanisms underlying drug resistance in *A. baumannii*: β-lactamase production, AMEs, and 16S rRNA methylase, efflux pump overexpression, antibiotic target location alterations, Omp permeability alterations, and biofilm formation. Created with BioRender.com.

Front. Microbiol. 15:1332108.

Why is *Acinetobacter baumannii* so relevant?

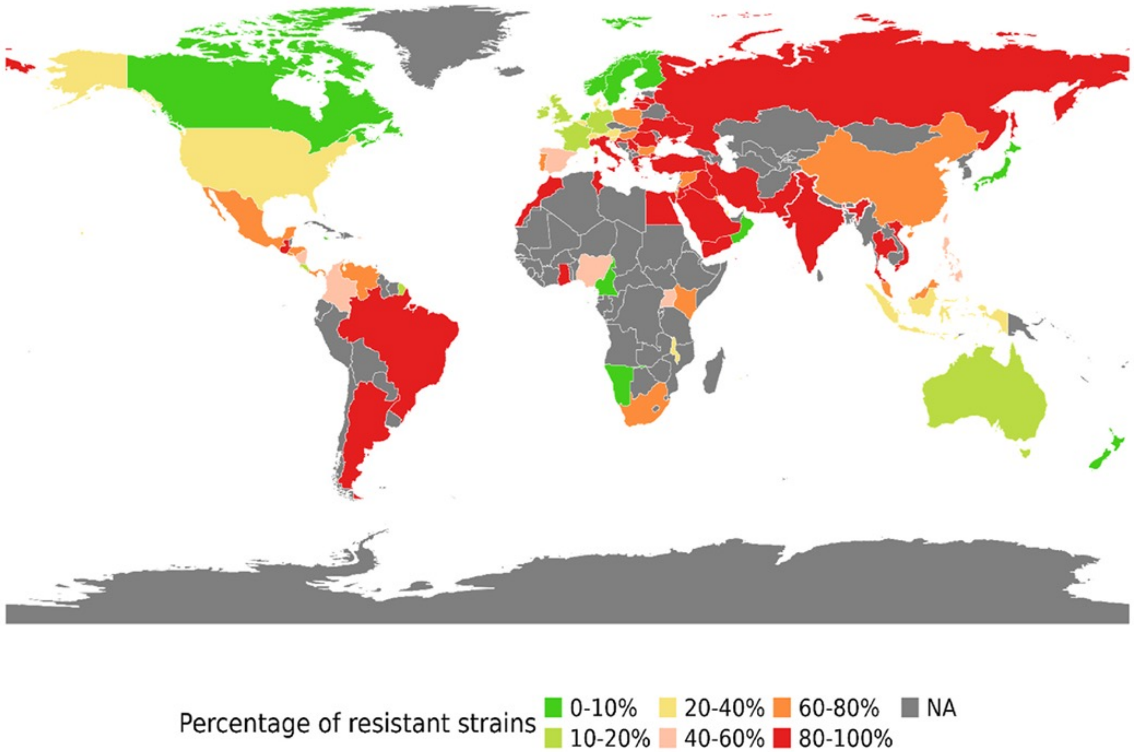

Fig. 1. Global distribution of carbapenem-resistant *Acinetobacter baumannii* strains from 2004 to 2022. Countries with the highest percentage of resistant strains are shown in dark red, while those with the lowest percentage are depicted in green. Regions with no available data or reported cases are indicated in grey. Map generated using Rstudio 4.4.0. **Map lines do not necessarily depict accepted national boundaries.** (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

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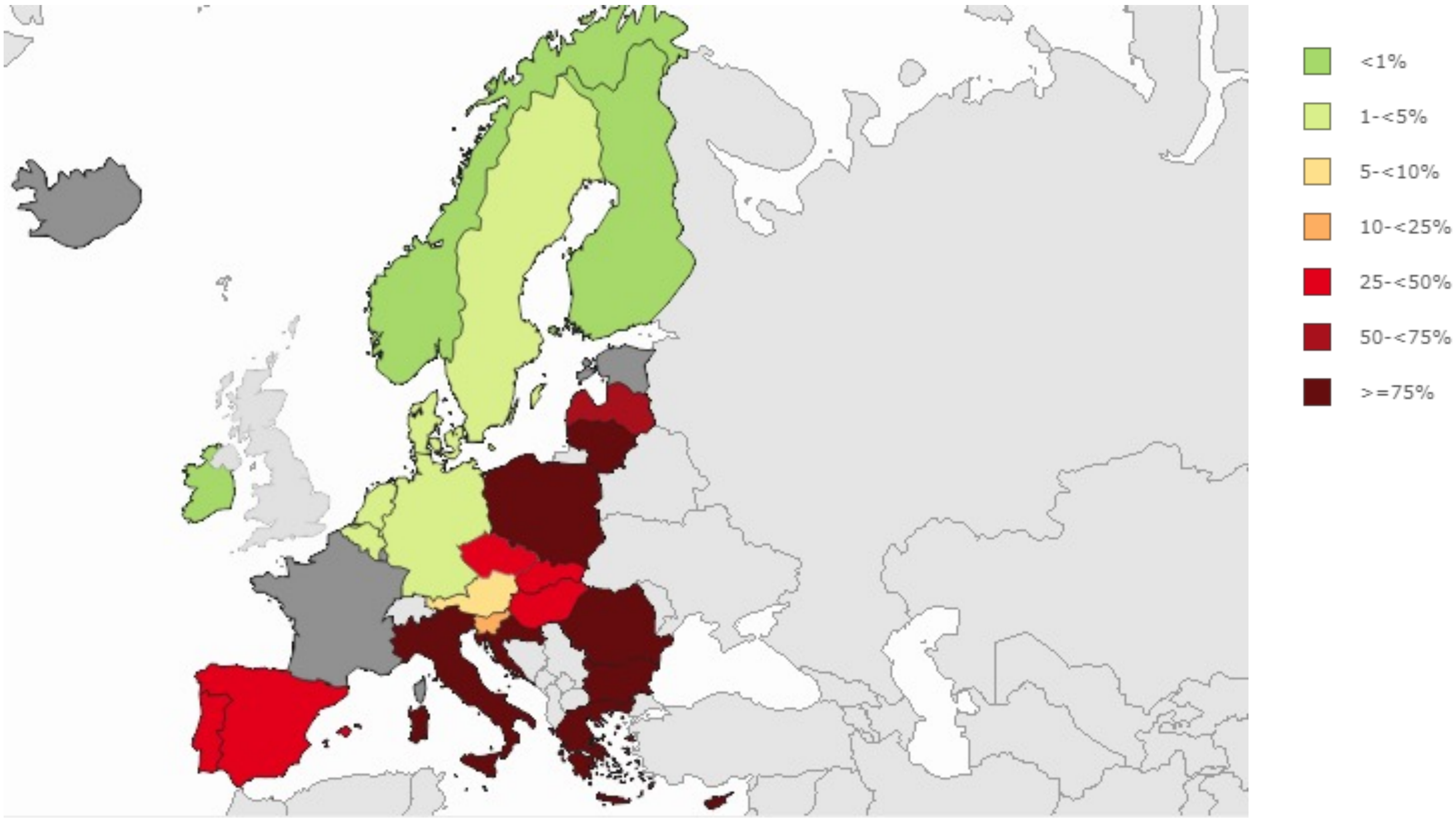
Microbial Pathogenesis 204 (2025) 107605

Surveillance Atlas of Infectious Diseases

2023



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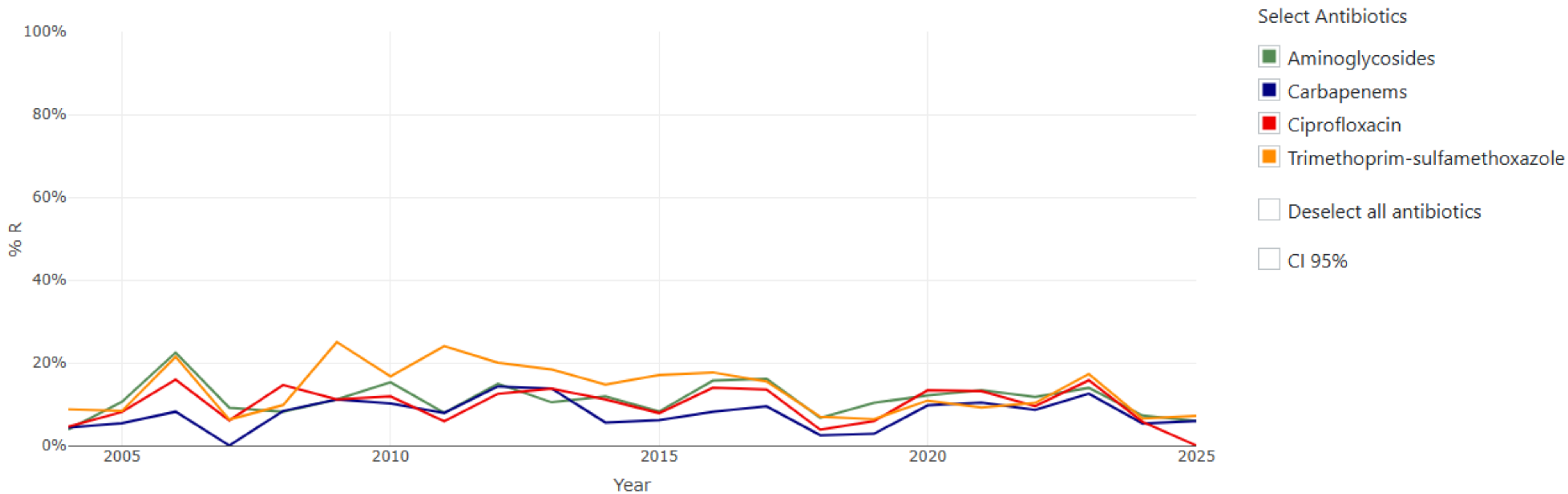
https://atlas.ecdc.europa.eu/public/index.aspx

What about Switzerland?



https://www.anresis.ch/

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Situation at our hospital

End of June and end of July 2022:

Detection of a MDR *Acinetobacter baumannii* on admission screening in **2 repatriated patients**

- both admitted to the burn ICU
- Since admission contact precautions

2. Acinetobacter baumannii	MHK [mg/l]	Interpretation	Breakpoints S		Breakpoints R	
Colistin	=1.0	S	<=	2.00	>	2.00
Eravacyclin	<=0.5mg/L susceptible			-		-

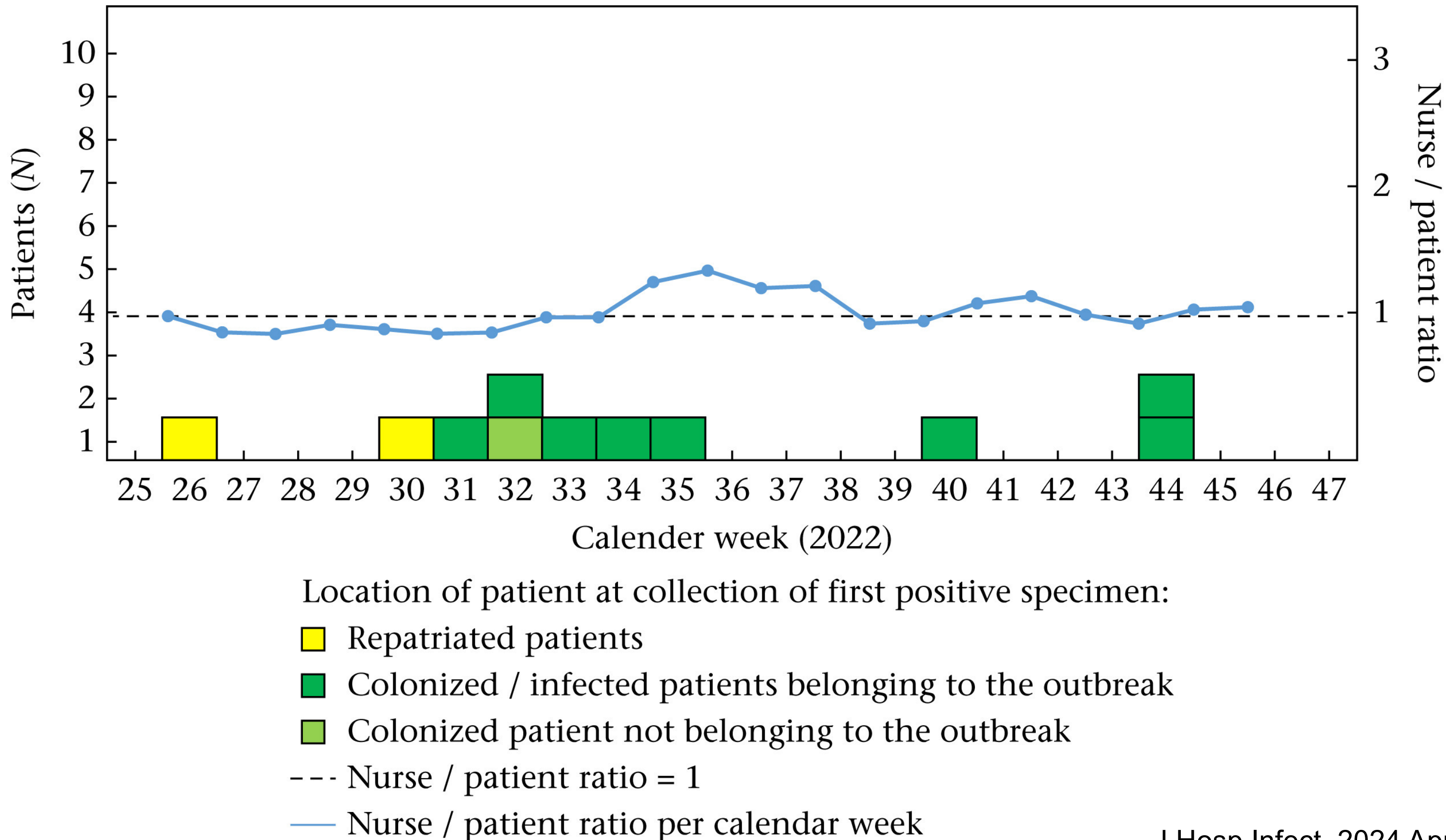
S = sensibel, I = sensibel bei erhöhter Dosierung, R = resistent, K = keine Interpretation
Interpretation nach EUCAST

2. Acinetobacter baumannii	MHK [mg/l]	Interpretation	Breakpoints S		Breakpoints R	
Ceftazidim / Avibactam	>=256.0	R	<=	8.00	>	8.00
Ceftolozane-Tazobactam	=48.0	R	<=	4.00	>	4.00
Meropenem-Vaborbactam	=48.0	R	<=	8.00	>	8.00
Tigecyclin	=2.0	R	<=	0.50	>	0.50

Cefiderocol: 22mm (>= 17 mm susceptible)

	1
Piperacillin/ Tazobactam	R
Ceftazidim	R
Cefepim	R
Imipenem	R
Meropenem	R
Gentamicin	R
Tobramycin	R
Amikacin	R
Ciprofloxacin	R
Levofloxacin	R
Sulfamethox.-Trimethop.	R

Situation at our hospital



J Hosp Infect. 2024 Apr:146:102-108.

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Situation at our hospital

Table II
Patient characteristics

Variable	Total patients (N=27)	Patients colonized/ infected with outbreak strain (N=8)[a]	Patients not colonized/ infected with outbreak strain (N=18)
Age in years, median (IQR)	39.0 (32.5–58.5)	34.5 (22.5–65.0)	40.0 (35.0–56.0)
Female sex	8 (29.6%)	3 (37.5%)	5 (27.8%)
Burn patient	21 (77.8%)	8 (100%)	12 (66.7%)
Percentage of body surface area with burn lesions ≥2a, median (IQR)	25.5% (17.0–33.5)	29.8% (23.5–37.3)	22.3% (0.0–32.5)
Admission via resuscitation room	21 (77.8%)	8 (100%)	12 (66.7%)
Operations until event or end of ICU stay, median (IQR)	2 (1–4)	2 (2–4)	2 (0–2)

IQR, interquartile range; ICU, intensive care unit.
[a] One patient with multi-drug-resistant *Acinetobacter baumannii* featuring different typing results by Fourier-transform infra-red spectroscopy and multi-locus sequence typing was excluded.

J Hosp Infect. 2024 Apr:146:102-108.

What have we done?

Table I
Containment measures

Assembling an interdisciplinary and multi-professional outbreak team
Stop on admissions for non-burn patients[a]
Contact isolation of colonized and/or infected patients
Spatial separation of colonized and non-colonized patients
Dedicated nursing
Weekly screening of non-colonized patients on the intensive care unit
Observation and review of daily routine by infection control staff
Training and staff education
Encouraging 'speak-up'
Enhanced disinfection (increased frequency, ultraviolet-C, vaporized hydrogen peroxide)
Emptying the burns centre for terminal cleaning
Support from infection prevention and control to regular wards hosting case patients after transfer
Contact isolation and repetitive screening of patients in regular wards receiving treatment in the operating theatre of the burns centre

[a] University Hospital Zurich is one of two national burns centres in Switzerland with a commitment to accept burn patients.

J Hosp Infect. 2024 Apr:146:102-108.

Situation at our hospital

Environmental testing

Location and type of sample	Number of samples	Presence of outbreak strain
Patient rooms and shared areas on burns ICU	8	
• Sink siphons	44	
• High-touch surfaces/medical devices	24	Multidrug-resistant *Acinetobacter baumannii* in one air sample during a dressing change of a colonized patient
• Air sampling		
Operation theatres for burns patients		-
• High-touch surfaces/medical devices	22	
• Air sampling	12	
Resuscitation room		-
• Sink siphons	1	
• High-touch surfaces/medical devices	16	
Endoscopy	5	-
Total	132	1

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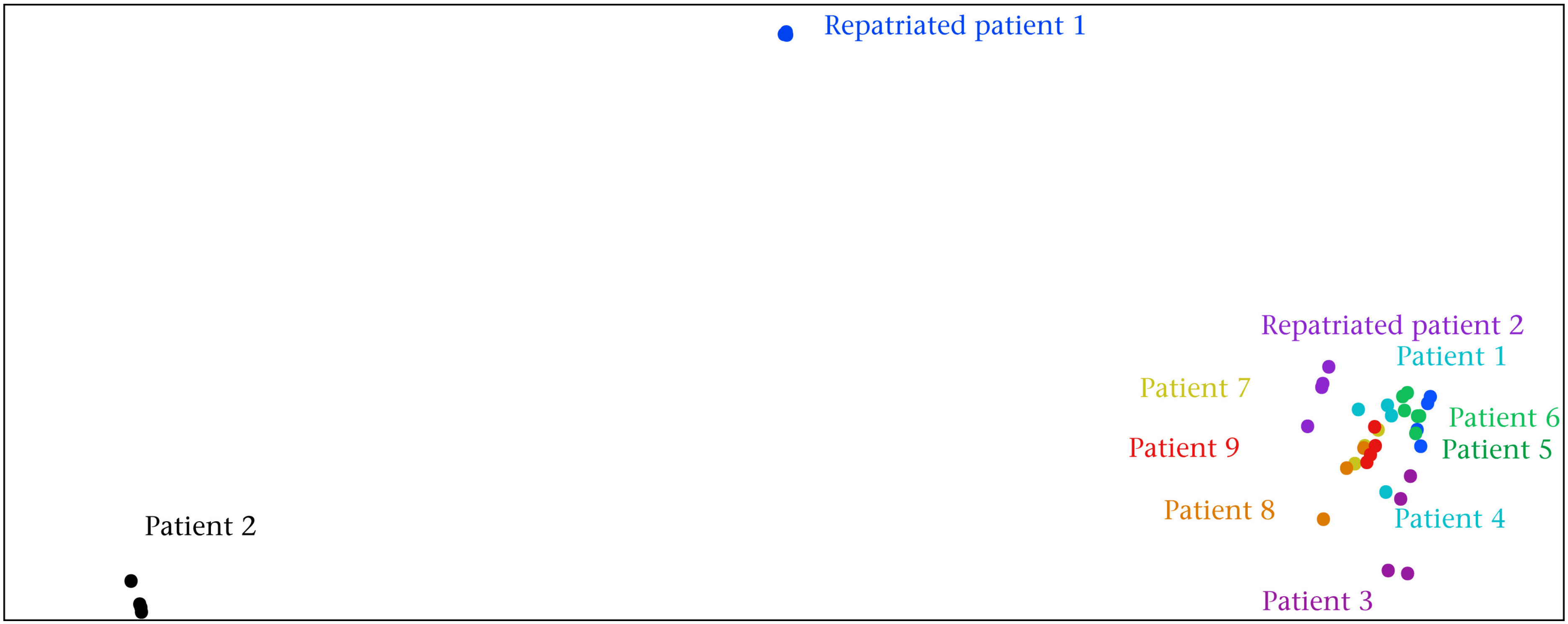
J Hosp Infect. 2024 Apr:146:102-108.

Typing with Fourier-transform infra-red (FT-IR) spectroscopy



MLST: all patients (except RP1) sequence type 2
ANI: ≥99.98% for all outbreak related strains, ≤98.04% for patient 2

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J Hosp Infect. 2024 Apr:146:102-108.

Situation at our hospital

Infections among colonized patients

- Nine infections
  - Four ventilator-associated pneumonias, two with bacteremia
  - Four wound infections
  - One primary bloodstream infection

Outcomes

- Two patients with death considered related to the outbreak strain

J Hosp Infect. 2024 Apr:146:102-108.

Risk factors for acquisition of the outbreak strain

Table III
Risk factor analysis for acquisition of the outbreak-related multi-drug-resistant *Acinetobacter baumannii*

Variable	OR (95% CI)	*P*-value
Age (per year increase)	0.99 (0.94–1.04)	0.64
Gender		0.62
Male	Reference	
Female	1.56 (0.24–9.99)	
Percentage of body surface area with burn lesions ≥2a (per percent increase)	1.05 (0.99–1.12)	0.09
Nurse-to-patient ratio (per 0.1 increase)	0.34 (0.10–1.12)	0.06
Number of bronchoscopies[a]	2.31 (0.97–7.94)	0.10
Number of upper gastrointestinal endoscopies[a]	1.18 (0.63–2.22)	0.59
Number of operative procedures[a]	1.19 (0.75–1.90)	0.43

OR, odds ratio; CI, confidence interval.
[a] Prior to first detection of the outbreak strain for patients colonized/infected with the outbreak strain or until discharge from the burns centre.

J Hosp Infect. 2024 Apr:146:102-108.

Why were there transmissions?

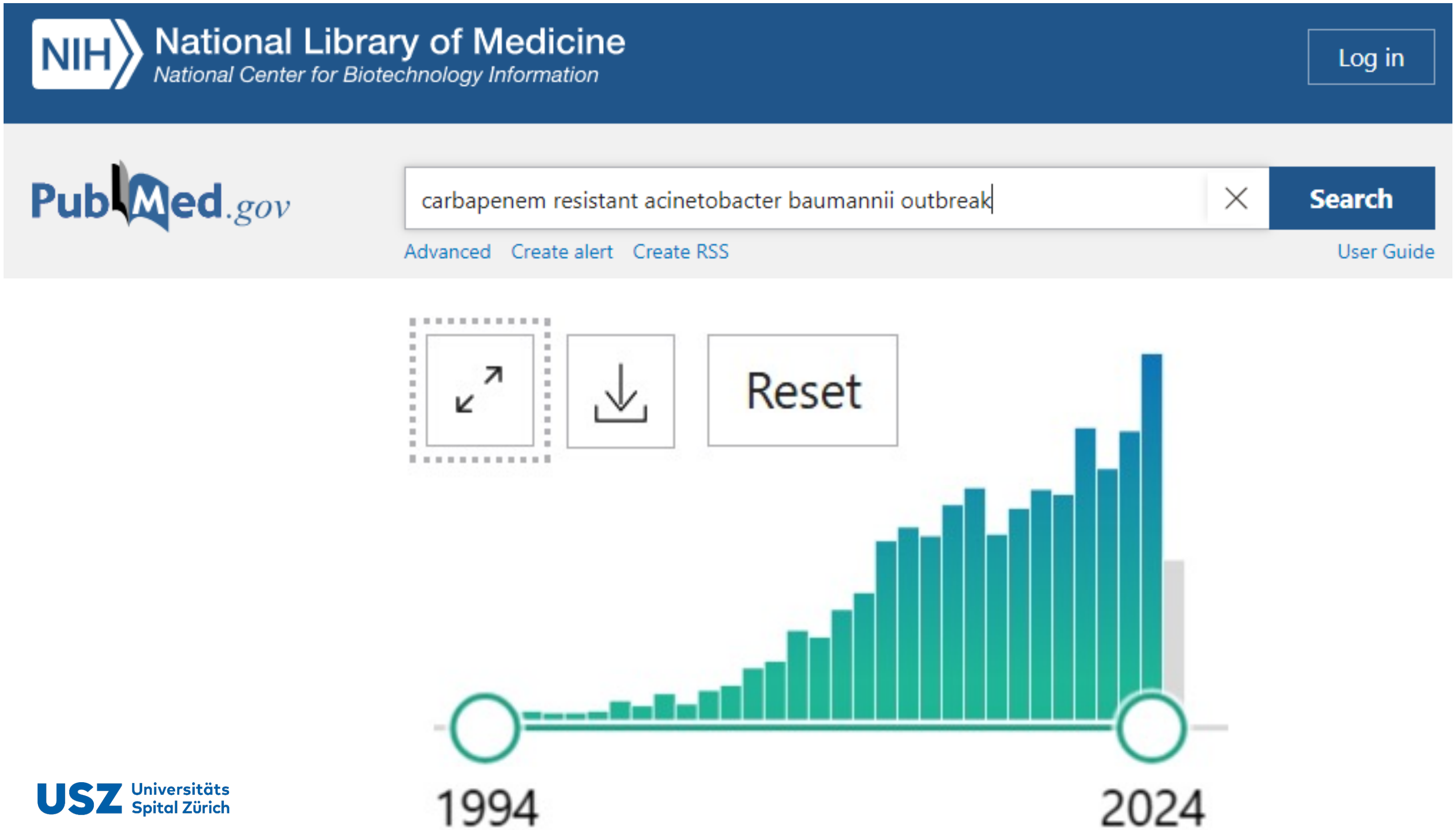
No hint of a common source in environmental sampling such as:

- High-touch surfaces
- Water systems
- Hydrotherapy
- Air samples in the OR
- Medical devices with contact to multiple patients, e.g. ultrasound, airway devices, ward trolleys

Likely propagated outbreak with transmission via hands and indirectly via contaminated surfaces. Transmission occured predominantly in periods with:

- High patient numbers
- Without dedicated nursing of colonized patients
- High proportion of float nurses

How common is this problem?



How is *A. baumannii* transmitted?

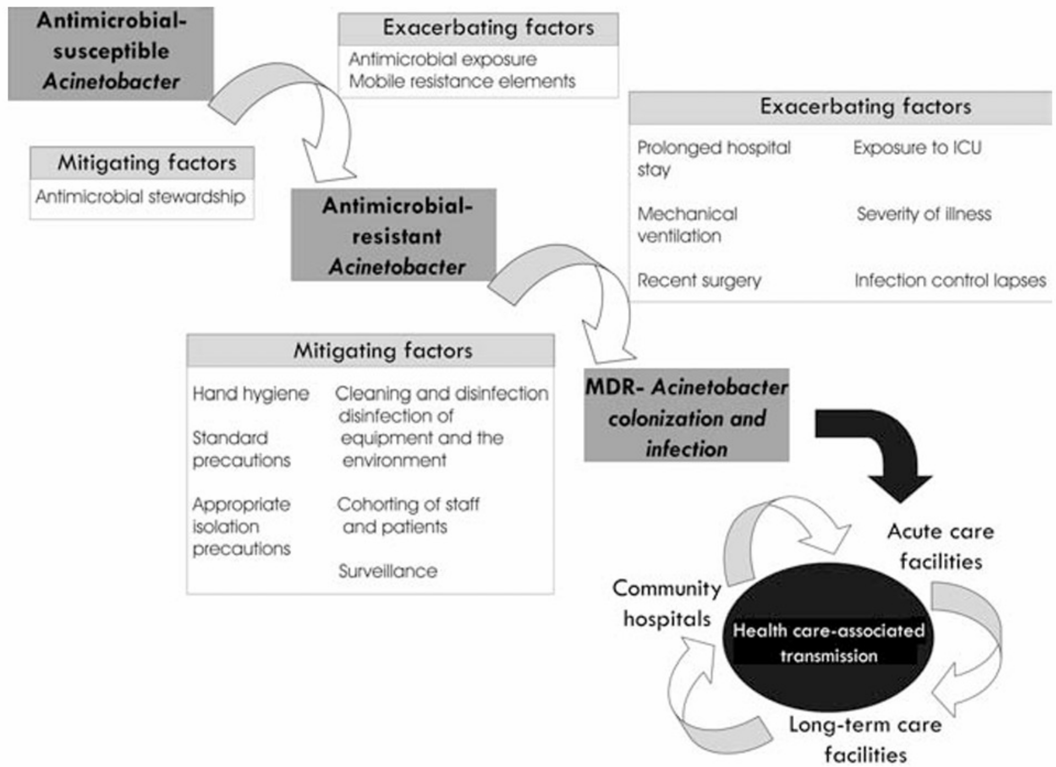


Figure 1. Factors leading to the emergence and transmission of multidrug-resistant (MDR) *Acinetobacter* species. ICU, intensive care unit.

Clin Infect Dis. 2008 Apr 15;46(8):1254-63.

Reported risk factors for *A. baumannii* transmission

Factors Leading to Transmission Risk of *Acinetobacter baumannii**

Kerri A. Thom, MD, MS[1]; Clare Rock, MD, MS[2]; Sarah S. Jackson, MPH[1]; J. Kristie Johnson, PhD[1];
Arjun Srinivasan, MD[3]; Laurence S. Magder, PhD[1]; Mary-Claire Roghmann, MD, MS[1,4]; Robert A. Bonomo, MD[5];
Anthony D. Harris, MD, MPH[1]

Objectives: To identify patient and healthcare worker factors associated with transmission risk of *Acinetobacter baumannii* during patient care.

Design: Prospective cohort study.

Setting: University of Maryland Medical Center IMCs and ICUs.

Patients: 52 adult ICU patients known to be infected or colonized with *A. baumannii*.

Measurements and Main Results:

- Cultures of skin, respiratory tract, and the perianal area were obtained from participants and evaluated for the presence of *A. baumannii*.
- Healthcare worker patient interactions were observed.
- Healthcare worker hands/ gloves were sampled at room exit for the presence of *A. baumannii*.

Crit Care Med 2017; 45:e633–e639

Reported risk factors for *A. baumannii* transmission

TABLE 1. *Acinetobacter baumannii* Cohort Characteristics

	Acinetobacter baumannii-Positive Patients (*n* = 52)
Age, mean (SD)	54.5 (15)
Men, *n* (%)	36 (69)
Location ICU (vs IMC), *n* (%)	45 (87)
Surgical ICU	5 (10)
Neurocare ICU	5 (10)
Medical ICU	16 (31)
Neurotrauma ICU	8 (15)
Multitrauma ICU	8 (15)
Select trauma ICU	3 (6)
Neurotrauma IMC	5 (10)
Multitrauma IMC	2 (4)
Charlson comorbidity index, mean (SD)	2.8 (3)
Artificial airway, *n* (%)	41 (79)
Urinary catheter, *n* (%)	29 (56)
Central venous catheter, *n* (%)	43 (83)
Wounds, *n* (%)	27 (52)
Diarrhea, *n* (%)	28 (54)
Antibiotics, *n* (%)	46 (88)

TABLE 3. Factors Associated With Potential Transmission of *Acinetobacter baumannii* Multivariate, Generalized Linear Mixed Model, Regression

Variable	OR (95% CI) *n* = 254
Study culture positive (no. of sites positive)	
0	1.67 (0.07–41.24)
1	Reference
2	1.42 (0.45–4.52)
3	1.94 (0.50–7.49)
Multidrug-resistant *Acinetobacter baumannii*	
No	Reference
Yes	4.78 (1.24–18.45)
HCW touched bed rail	
No	Reference
Yes	2.19 (1.00–4.82)
HCW performed wound dressing	
No	Reference
Yes	8.35 (2.07–33.63)
HCW interacted with endotracheal tube/tracheotomy site	
No	Reference
Yes	5.15 (2.10–12.60)

HCW = healthcare worker, OR = odds ratio.

Crit Care Med 2017; 45:e633–e639

Reported risk factors for *A. baumannii* transmission

Conclusions:

- Healthcare worker hands/gloves are frequently contaminated with *A. baumannii* after patient care.
- Patient-level factors were not associated with an increased transmission risk
- However, having multidrug-resistant-*A. baumannii* and specific healthcare worker activities led to an increased contamination risk.
- Our findings reveal a potential selective advantage possessed by multidrug-resistant-*A. baumannii* in this environment and suggest possible areas for future research.

Crit Care Med 2017; 45:e633–e639

Environmental sampling

pathogens MDPI

You can contaminate the environment and create a potential common source!

Brief Report

Dissemination of Clinical *Acinetobacter baumannii* Isolate to Hospital Environment during the COVID-19 Pandemic

Emina Pustijanac [1,*,†], Jasna Hrenović [2,†], Mirna Vranić-Ladavac [3], Martina Močenić [4], Natalie Karčić [3], Lorena Lazarić Stefanović [4], Irena Hrstić [4], Jasenka Lončarić [4], Martina Šeruga Musić [2], Marina Drčelić [2], Dijana Majstorović [5] and Ines Kovačić [6]

General Hospital Pula, a 427-bed hospital in the city of Pula, Croatia. From 1 December 2020, until 6 June 2021, an eight-bed intensive care unit (ICU) for COVID-19 patients was established at the former location of this hospital. During this period, 67 patients with severe COVID-19 symptoms were hospitalized in the ICU, and 29 of them acquired a co-infection with *A. baumannii*.

Table 2. Origin, date of isolation, and molecular identification of *A. baumannii* * isolates from general hospital Pula.

Isolate	Origin	Date of Isolation	Sequence Type (ST)
1524	air conditioner	7 April 2021	208
113	bronchial aspirate	5 January 2021	208
737	tracheal aspirate	18 January 2021	208
798	bronchoalveolar aspirate	19 January 2021	208
809	tracheal aspirate	19 January 2021	208

* MALDI-TOF MS provided high-confidence species identification for *A. baumannii* with score values from 2.10 to 2.36.

Pathogens 2023, 12, 410.

Environmental sampling

TABLE 1 Characteristics of the participating ICUs and CRAB isolates from sinks and clinical samples.

Hospital	ICU no[a]	ICU beds	Sink no.	Positive sinks (%)	CRAB clinical isolate no.
Chengdu First People's Hospital	1G	60	13	2(15.4)	16
	1 N	36	8	0(0)	0
Chengdu Second People's Hospital	2G	22	11	7(63.6)	4
	2 N	20	4	1(25.0)	0
The First Affiliated Hospital of Chengdu Medical College	3G	28	11	4(36.4)	4
Sichuan Provincial People's Hospital	4G	32	9	2(22.2)	3
	4 N	45	15	0(0)	0
Affiliated Hospital of Chengdu University	5G	22	10	0(0)	…
	5 N	16	4	0(0)	…
Chengdu Public Health Center	6G	16	16	0(0)	…
Chengdu Women and Children's Hospital	7 N	80	6	0(0)	…
Sichuan Women and Children's Hospital	8 N	80	16	0(0)	…
Sichuan Integrative Medicine Hospital	9G	25	15	0(0)	…
	9 N	5	2	0(0)	…
Chengdu Third People's Hospital	10G	24	4	0(0)	…
West China Hospital, Sichuan University	11G	50	14	0(0)	…
Total	16	561	158	16(10.1)	27

CRAB, carbapenem-resistant *Acinetobacter baumannii*; ICU, intensive care unit.
[a]In this column, G indicates general ICU; N indicates neonatal ICU; no sink was positive for CRAB at the participating ICUs and not to collect CRAB clinical isolates.

Handwashing sinks as reservoirs of carbapenem-resistant *Acinetobacter baumannii* in the intensive care unit: a prospective multicenter study

Li Wei[1,2], Yu Feng[3], Ji Lin[2], Xia Kang[2], Hongdi Zhuang[2], Hongxia Wen[1,3], Shasha Ran[4], Lan Zheng[5], Yujing Zhang[6], Qian Xiang[7], Yan Liu[8], Xueqin Wu[9], Xiaofei Duan[10], Wensheng Zhang[11], Qu Li[12], Hua Guo[13], Chuanmin Tao[1]* and Fu Qiao[2]*

Front Public Health. 2024 Oct 9;12:1468521.

Environmental sampling

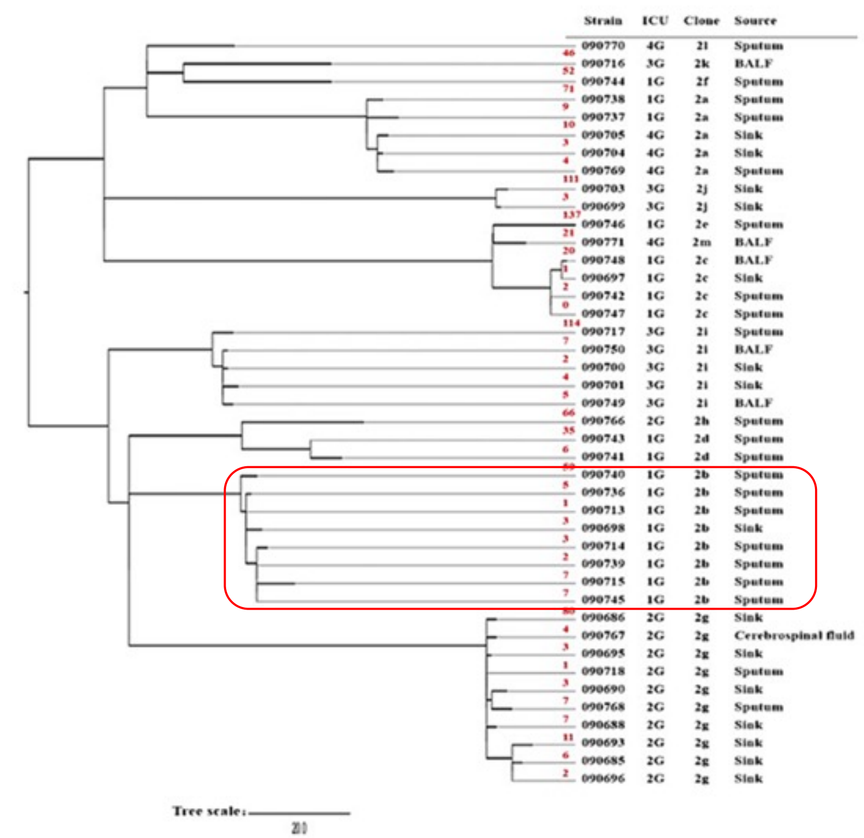


FIGURE 1

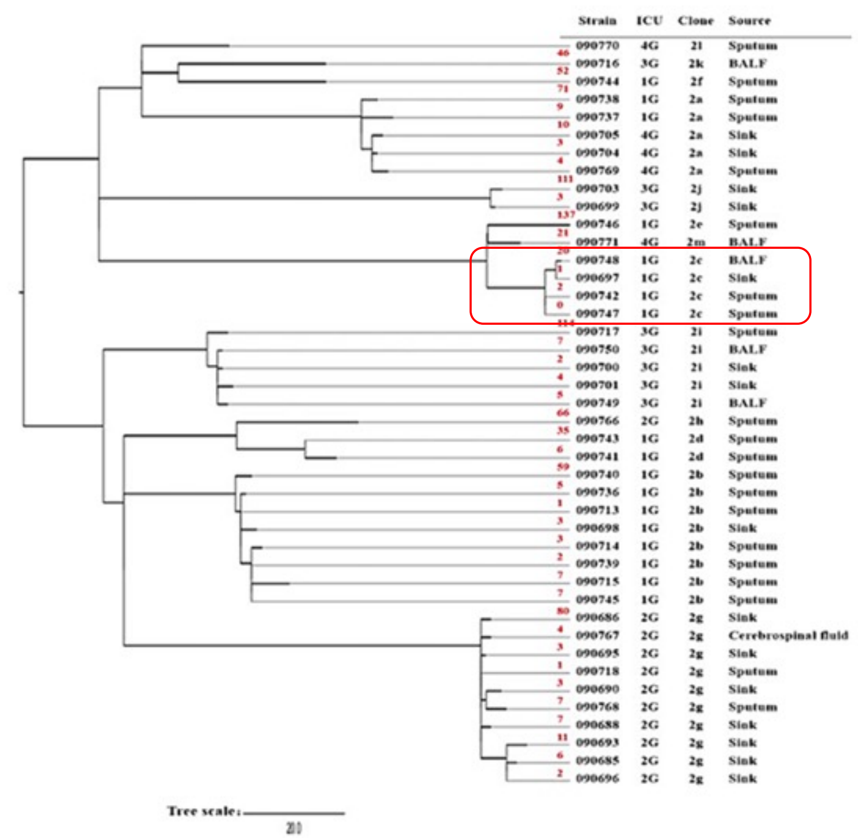
Phylogenetic trees of sequence type (ST) 2 carbapenem-resistant *Acinetobacter baumannii* strains. Shown are the strain name, the ICU where the strain was recovered (see Table 1), and the clone to which the strain belonged (see Table 2). The number of single-nucleotide polymorphisms between the adjacent two strains is indicated in red. Abbreviations: BALF, bronchoalveolar lavage fluid; ICU, intensive care unit.

Seven clinical isolates recovered from sputum, along with one sink isolate (090698), harbored both blaOXA-23 and blaOXA-6. These strains shared 1–7 SNPs, and therefore belonged to a common clone (clone 2b) (Figure 1), indicating an outbreak.

Four of these seven clinical isolates were recovered before the sink sampling date, and the other three clinical isolates (090739, 090740, and 090745) were recovered after the sink sampling date.

Front Public Health. 2024 Oct 9;12:1468521.

Environmental sampling



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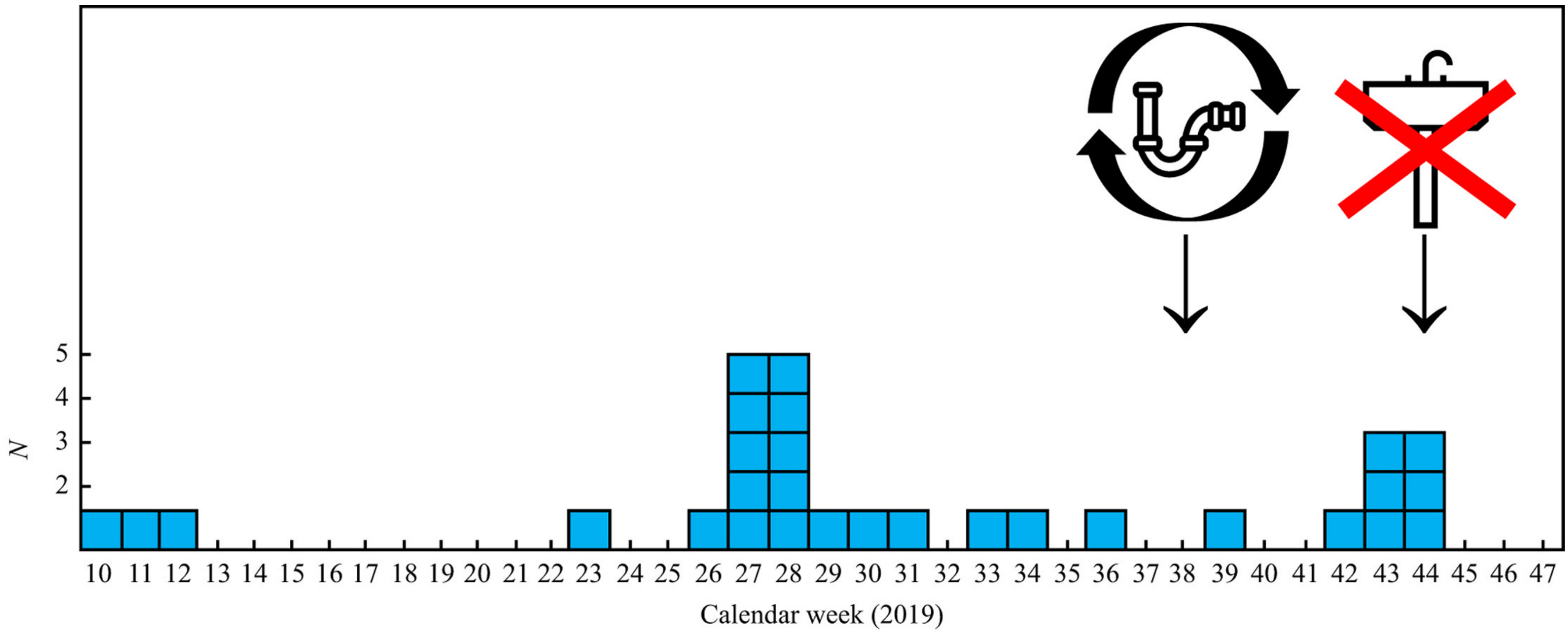
Another isolate (090697) from another sink shared 0–2 SNPs with three clinical isolates and therefore belonged to a common clone (clone 2c).

All three clinical isolates were recovered at a later date than the sink sampling date; therefore, the sink was likely to be the route of infection transmission.

Front Public Health. 2024 Oct 9;12:1468521.

Sink contamination can matter!



J Hosp Infect. 2023 Sep:139:161-167.

Environmental sampling

🔓 | Bacteriology | Research Article

The VBNC state: a fundamental survival strategy of *Acinetobacter baumannii*

Patricia König,[1] Alexander Wilhelm,[2] Christoph Schaudinn,[3] Anja Poehlein,[4] Rolf Daniel,[4] Marek Widera,[2] Beate Averhoff,[1] Volker Müller[1]

The viable but non-culturable (VBNC) state is a persistence strategy adopted by bacteria to withstand long-lasting periods of unfavorable conditions.

Here, we report an additional, novel survival strategy of *A. baumannii*. Upon prolonged incubation in high-salt media, cells became unculturable. However, LIVE/DEAD staining followed by flow cytometry, respiratory activity assays, and resuscitation experiments revealed that these cells were viable but non-culturable.

mBio. 2023 Oct 31;14(5):e0213923.

Environmental sampling

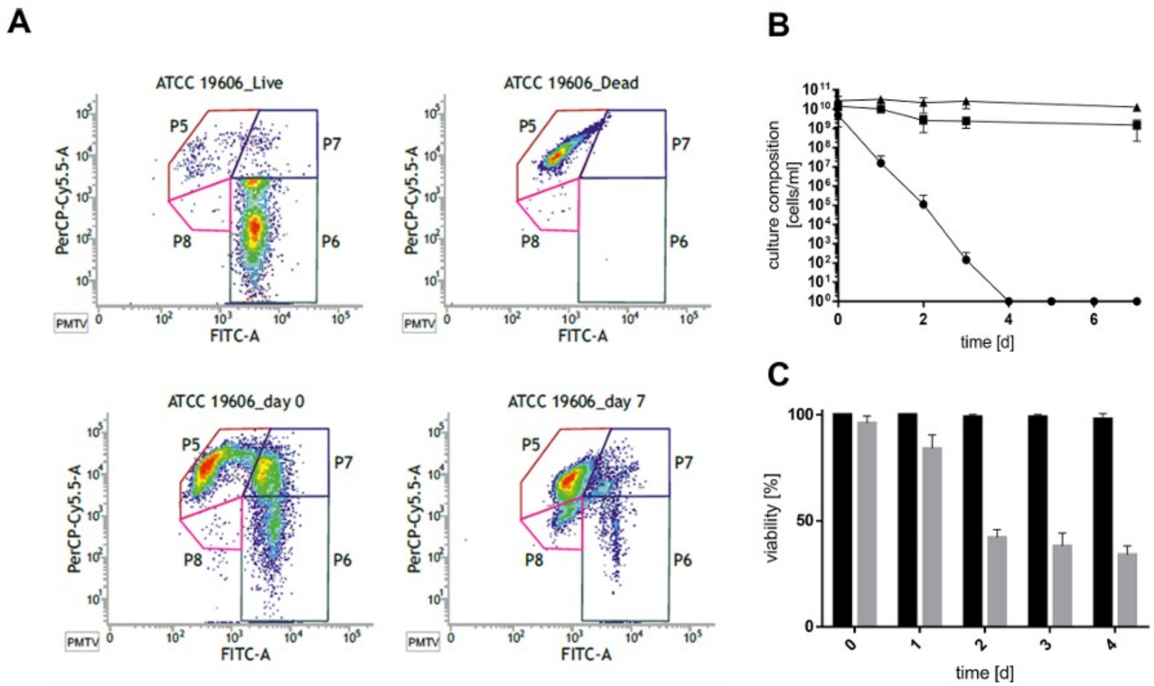


FIG 2 Survival under high-salt conditions as determined by LIVE/DEAD and CTC staining. *A. baumannii* ATCC 19606[T] was grown in minimal medium with 20 mM succinate and 300 mM NaCl to the stationary growth phase (timepoint 0 [T0]) and for further 7 days. Cells were stained with the LIVE/DEAD BacLight Bacterial Viability Kit according to manufacturer's instructions and analyzed by flow cytometry. Representative density plots from at least three independent biological replicates are shown (A). The viable cell count (■) is defined as the sum of populations 6 and 7, while the total cell count (▲) is defined as the sum of populations 5–8 and quantified using the kit's microsphere standard. The culturable cell count (●) was determined by serially diluting the culture and plating samples onto LB agar plates (B). The respiratory activity of cells either grown in low- (black bars) or high-salt (gray bars) mineral medium was determined by using the BacLight RedoxSensor CTC Vitality Kit according to manufacturer's instructions. Cells were counterstained with DAPI and visualized with CLSM prior to counting (C). Error bars denote the standard deviation of the mean derived from at least three independent biological replicates.

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31;14(5):e0213923.

Outbreak reports and containment measures

The challenge of preventing and containing outbreaks of multidrug-resistant organisms and *Candida auris* during the coronavirus disease 2019 pandemic: report of a carbapenem-resistant *Acinetobacter baumannii* outbreak and a systematic review of the literature

Reto Thoma[1†], Marco Seneghini[1*†], Salomé N. Seiffert[2], Danielle Vuichard Gysin[3], Giulia Scanferla[1], Sabine Haller[1], Domenica Flury[1], Katia Boggian[1], Gian-Reto Kleger[4], Miodrag Filipovic[4], Oliver Nolte[2], Matthias Schlegel[1] and Philipp Kohler[1]

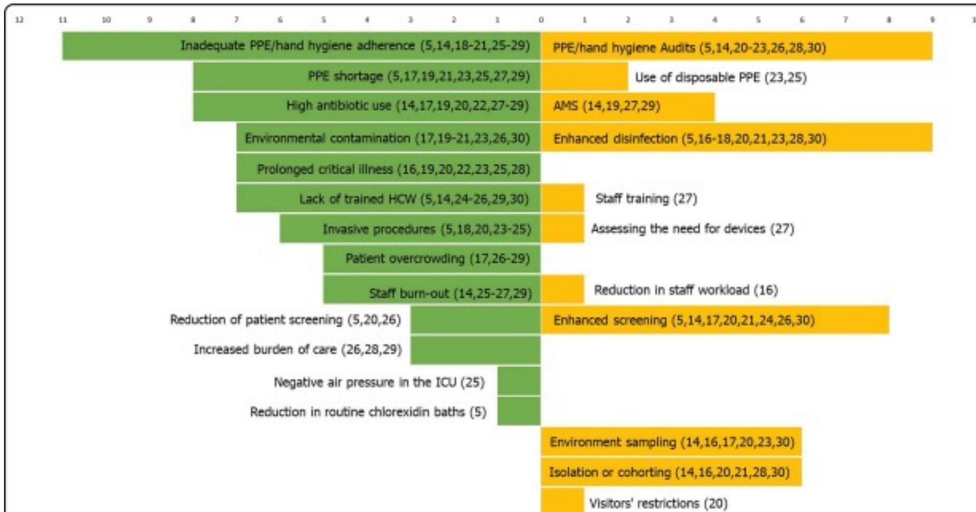

Fig. 4 Tornado diagram showing number of outbreaks reporting specific risk factors (in green) and corresponding containment measures (in yellow). Numbers in brackets denote study references. *PPE* personal protective equipment, *HCW* health-care worker, *ICU* intensive care unit, *AMS* antimicrobial stewardship

Antimicrob Resist Infect Control. 2022 Jan 21;11(1):12.

Outbreak reports and containment measures

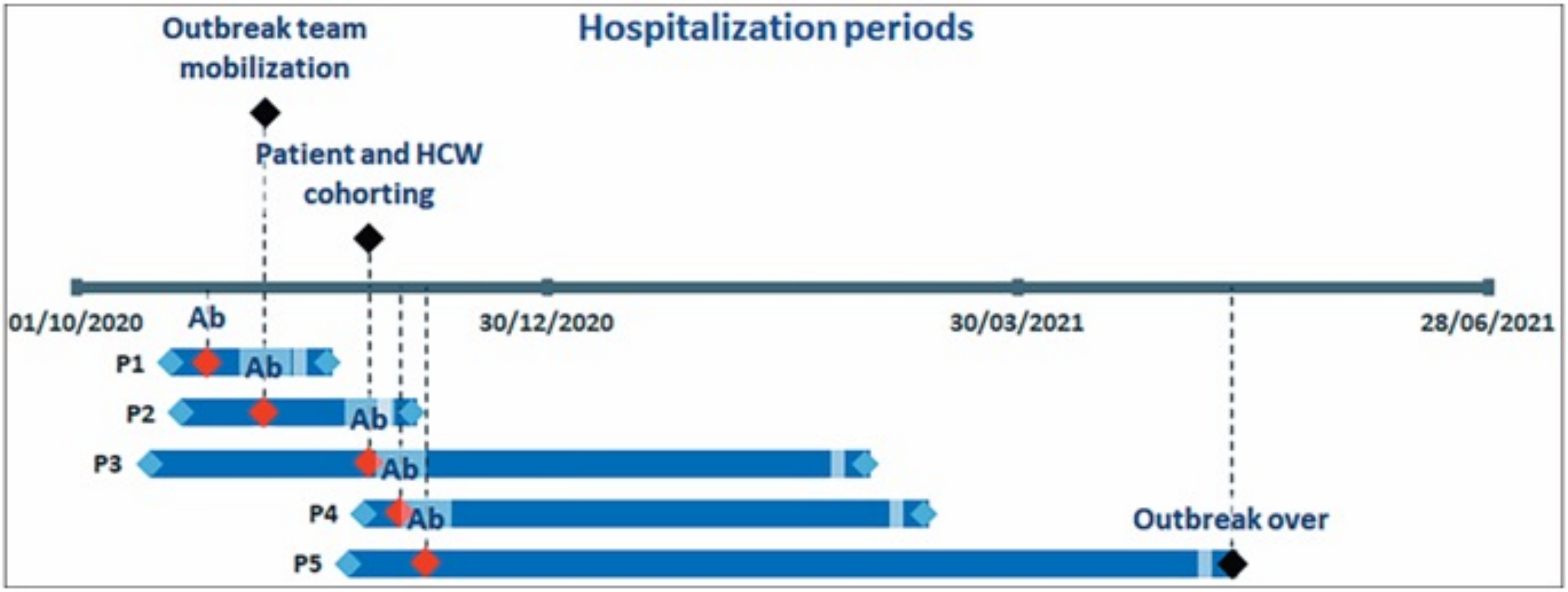

Fig. 2 - Extensively drug-resistant (XDR) *Acinetobacter baumannii* outbreak timeline. The blue lines represent the hospitalization periods, the red dots the dates at which the first XDR *Acinetobacter baumannii* isolates were detected in each patient. P1: index case. P2, P3, P4, P5: second, third, fourth and fifth case, respectively.

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Outbreak reports and containment measures

Infection control measures

- All ICU patients were initially placed under contact and droplet precautions.
- Active screening for MDRO colonization on admission and thereafter weekly.
- XDR-Ab patients were cohorted inside the ICU with dedicated staff.
- Mandatory training course for all HCW on infection control measures.
- Evaluation of hand hygiene and excreta management.
- Overall, 30 samples were collected from the patients' direct environment as well as sinks, drains and various medical devices (all negative).
- Disinfection with surface product and hydrogen peroxide diffusion

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Outbreak reports and containment measures

antibiotics

Review

Is It Possible to Eradicate Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) from Endemic Hospitals?

Filippo Medioli [1], Erica Bacca [1], Matteo Faltoni [1], Giulia Jole Burastero [1], Sara Volpi [1], Marianna Menozzi [1], Gabriella Orlando [1], Andrea Bedini [1], Erica Franceschini [1], Cristina Mussini [2] and Marianna Meschiari [1,*]

Antibiotics 2022, 11(8), 1015; https://doi.org/10.3390/antibiotics11081015

Outbrea

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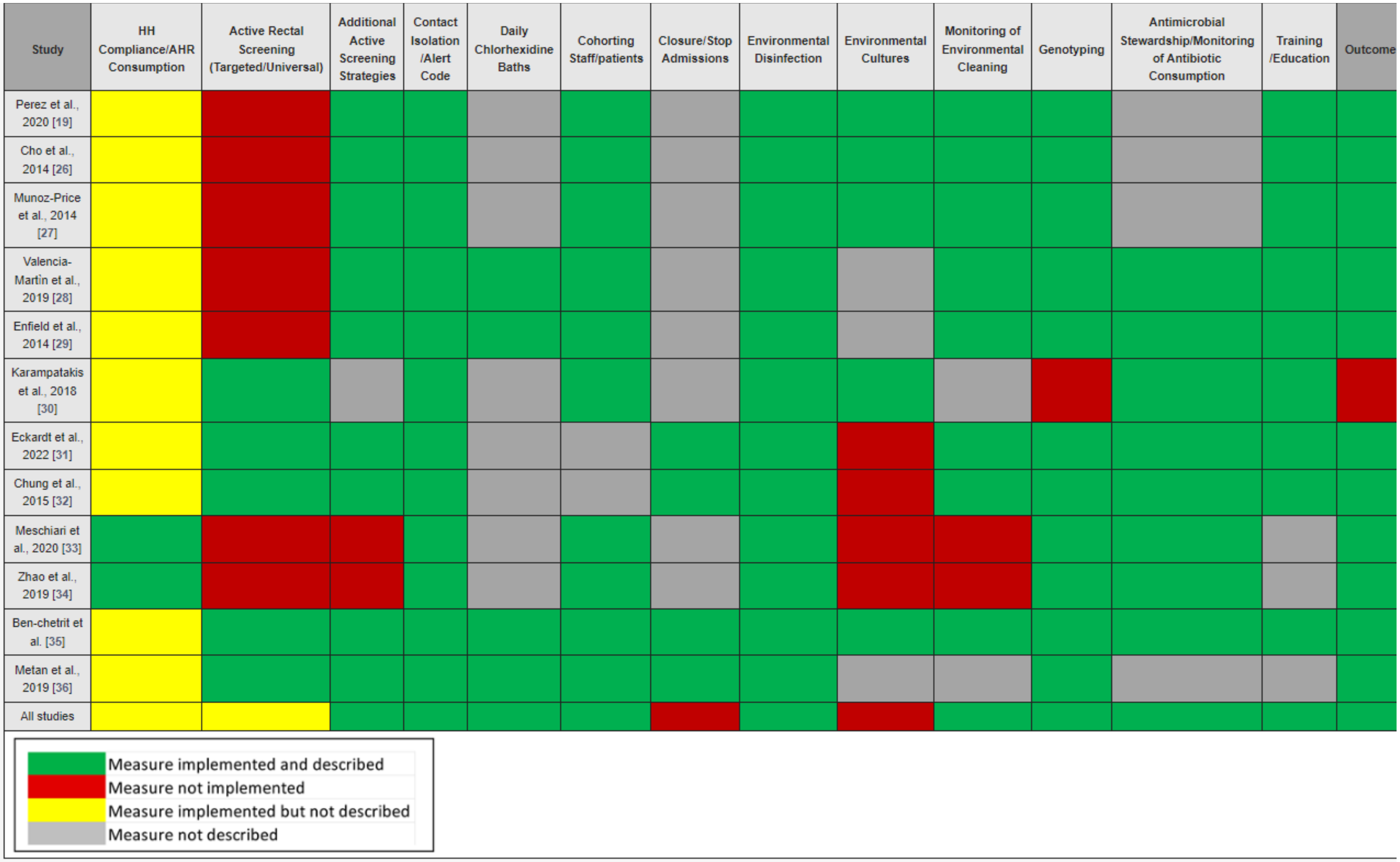
Review

Is It Possibl
baumannii (

Filippo Medioli [1], Eri
Gabriella Orlando [1]



Legend: AHR, alcohol-based hand rubs; BA, before and after study; BHI, brain–heart infusion medium; CMA, centered moving average; CRAB, carbapenem-resistant *Acinetobaster baumannii*; CRAB_ID CRAB, incidence density; CS, cross-sectional study; DDD, defined daily doses; ERIC-PCR, Enterobacterial repetitive intergenic consensus; HH, hand hygiene; ICU, intensive care unit; NA, not available; PGFE, pulsed-field gel electrophoresis; BA, before and after analysis; WGS, whole-genome sequencing.

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Antibiotics 2022, 11(8), 1015; https://doi.org/10.3390/antibiotics11081015

Outbreak reports and containment measures

Cycling radical cleaning procedure

A novel radical cleaning procedure was performed on April 12nd (Fig. 1B).

This method was applied only once and consisted of terminal cleaning and disinfection of each unit with 10% sodium hypochlorite for environmental surfaces and hydrogen peroxide in wipes for all medical devices.

The disinfectants were allowed to dry completely before re-using the surface. The common areas in the ICU were disinfected, then the colonized patient was moved from his original unit to the transitory unit in order to have the patient's original unit disinfected.

In the transitory unit, the patient's skin was disinfected with 2% leave-on chlorhexidine disposable cloths and he was transferred to his cleaned bed. Then the patient was relocated to the disinfected original unit and the transitory unit was subsequently disinfected.

The whole process takes in average 6 hto be completed needing the recruitment of an additional nurse shift and dedicated cleaning staff of 2 people. Cleaned surfaces were checked by infection control nurses using fluorescein spray with an UV torch.

Outbreak reports and containment measures

A. Intensive care unit (ICU) floor plan. The transitory area is highlighted in green.

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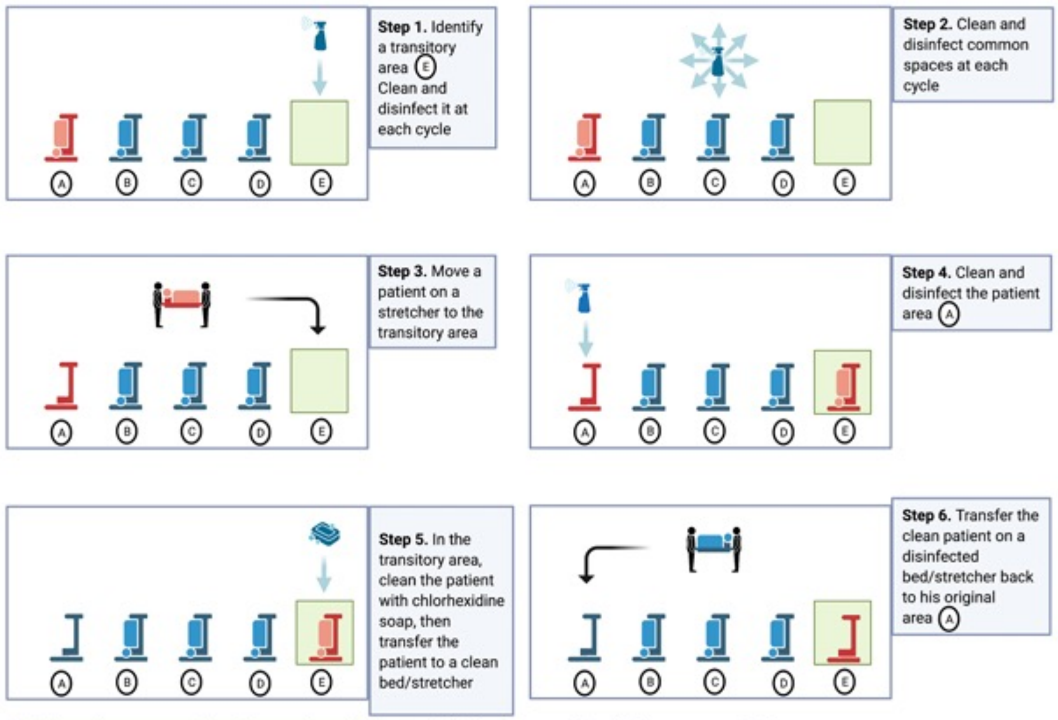
Antimicrob Resist Infect Control (2021) 10:123

Outbreak reports and containment measures



B. Schematic representation of the cycling cleaning and disinfection procedure in the open space ICU.

Fig. 1 The cycling disinfection procedure. The cycling disinfection procedure consisted of terminal cleaning and disinfection of each unit with 10% sodium hypochlorite for environmental surfaces and hydrogen peroxide in wipes for all medical devices, from upper corner to opposite lower corner starting from a transitory unit to be kept free. The common areas in the ICU were cleaned and disinfected, then the colonized patient was moved from his original unit to the transitory unit in order to have the patient's original unit disinfected. In the transitory unit, the patient's skin was disinfected with 2% leave-on chlorhexidine disposable cloths and he was transferred to his cleaned bed. Then the patient was relocated to the cleaned and disinfected original unit and the transitory unit was subsequently cleaned and disinfected. The whole process takes on average 6 h to be completed needing the recruitment of an additional nurse crew and dedicated cleaning staff

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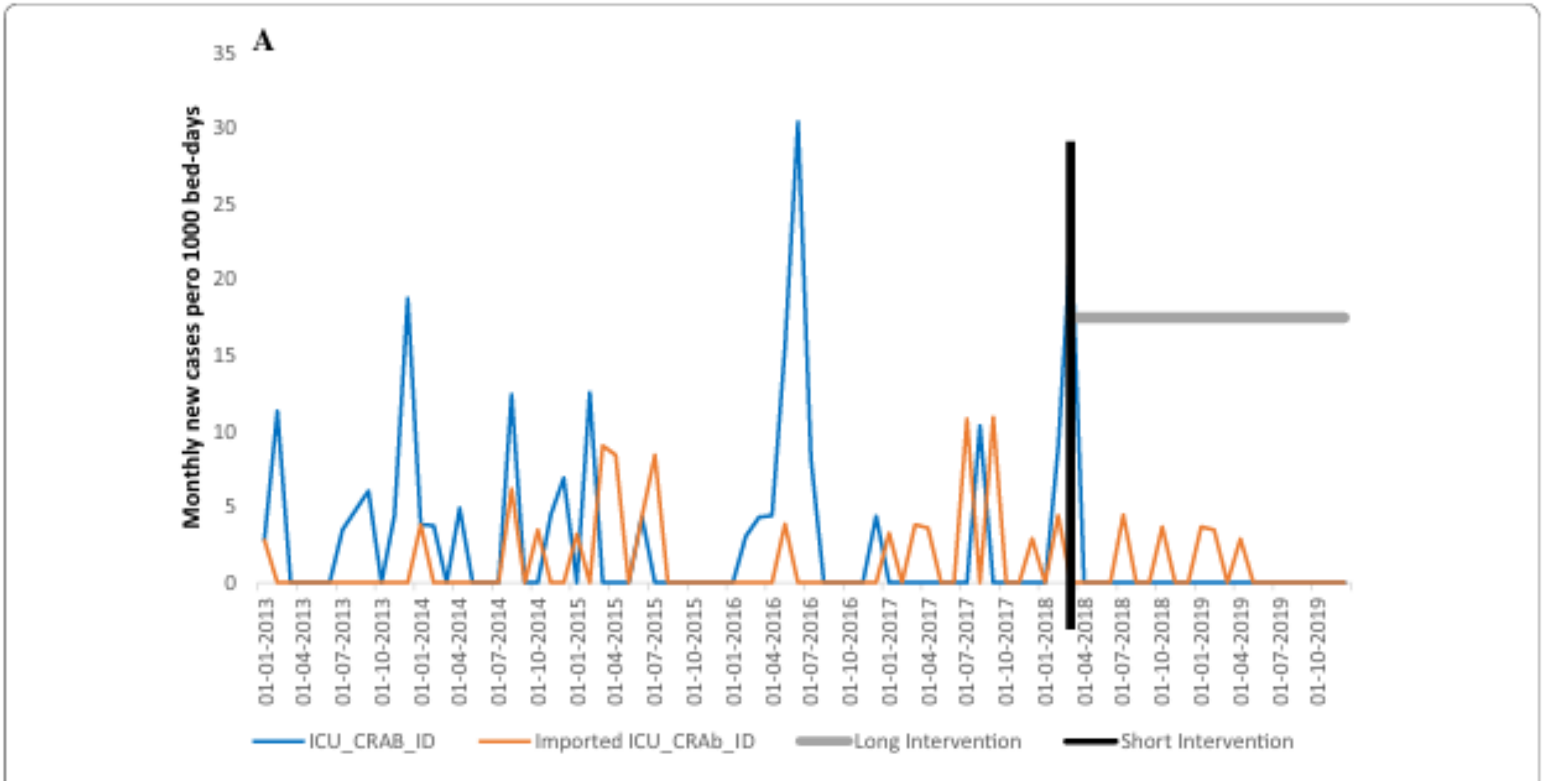
Outbreak reports and containment measures



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Outbreak reports and containment measures

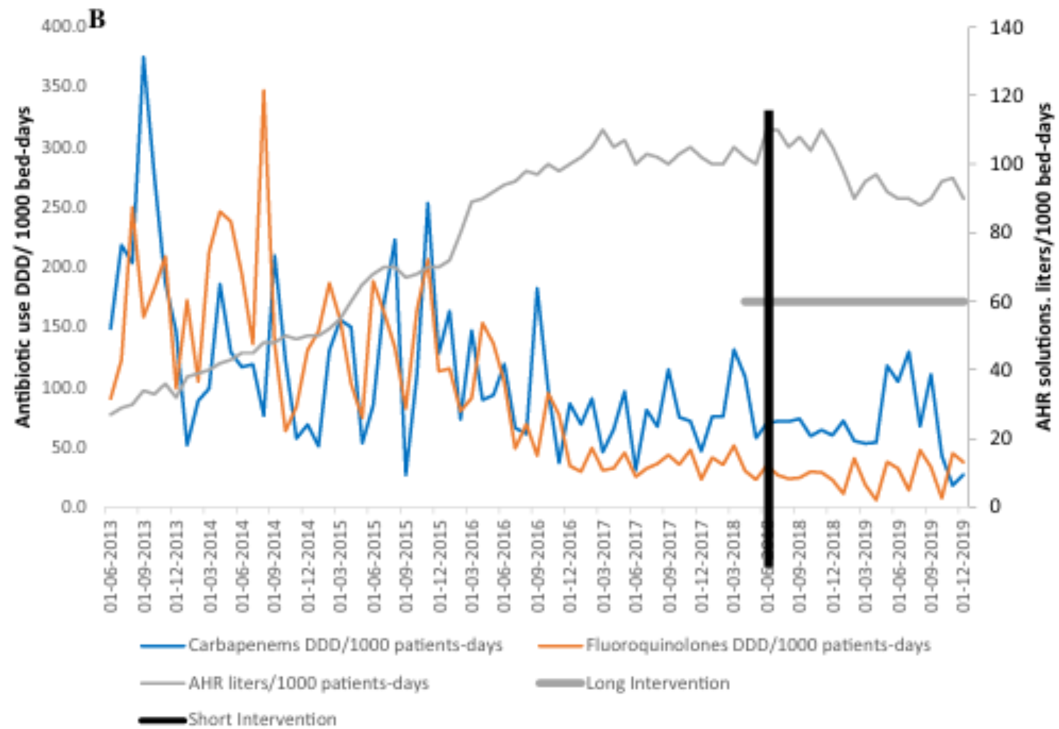

Fig. 3 Graphic representation of monthly Incidence Density of new nosocomial and imported cases of ICU CRAB (A); antibiotic and AHR consumptions (B), January 2013- January 2019. Thick grey line: long intervention. Black line: short intervention. **A** Blue line: nosocomial ICU-CRAB ID. **A** Orange line: imported-ICU-CRAB ID. **B** Blue line: Carbapenems DDD/1000 patients-days. **B** Orange line: Fluoroquinolones DDD/1000 patients-days. **B** Thin grey line: alcohol-based hand rub (AHR) consumption in litres /1000 patients-days. The multimodal intervention started on February 28th, 2018

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Nurse-to-patient ratio and transmissions

OPEN

A data-driven mathematical model of multi-drug resistant Acinetobacter baumannii transmission in an intensive care unit

SUBJECT AREAS:
BACTERIAL INFECTION
EPIDEMIOLOGY

Received
27 October 2014

Accepted
23 February 2015

Xia Wang[1*], Yong Chen[2*], Wei Zhao[2], Yan Wang[2], Qing Song[3], Hui Liu[3], Jingya Zhao[2], Xuelin Han[2], Xiaohua Hu[2], Hajo Grundmann[4], Yanni Xiao[1] & Li Han[2]

Nurse-to-patient ratio and tran...

Major challenges remain when attempting to quantify and evaluate the impacts of contaminated environments and heterogeneity in the cohorting of health care workers (HCWs) on hospital infections.

Data on the detection rate of multidrug-resistant *Acinetobacter baumannii* (MRAB) in a Chinese intensive care unit (ICU) were obtained to accurately evaluate the level of environmental contamination and also to simplify existing models.

Data-driven mathematical models, including mean-field and pair approximation models, were proposed to examine the comprehensive effect of integrated measures including cohorting, increasing nurse-patient ratios and improvement of environmental sanitation on MRAB infection.

Sci Rep. 2015 Mar 25:5:9478.

Nurse-to-patient ratio and transmissions

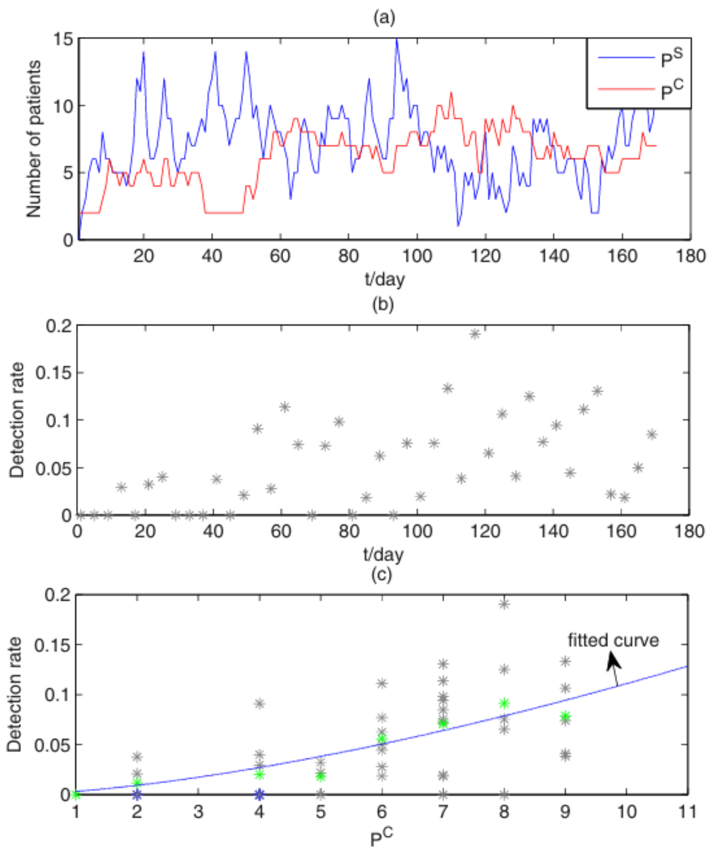

Figure 1 | (a) Time series of numbers of colonized and uncolonized Patients per day. Red lines, colonized patients; blue lines, uncolonized patients. (b) Detection rates of MRAB throughout the ward. (c) Correlations between detection rates and number of colonized patients. Gray stars - data; green stars - mean detection rate; the line - fitted curve.

Sci Rep. 2015 Mar 25:5:9478.

Nurse-to-patient ratio and transmissions

Indirect transmission rate 48.9

Indirect transmission rate 0

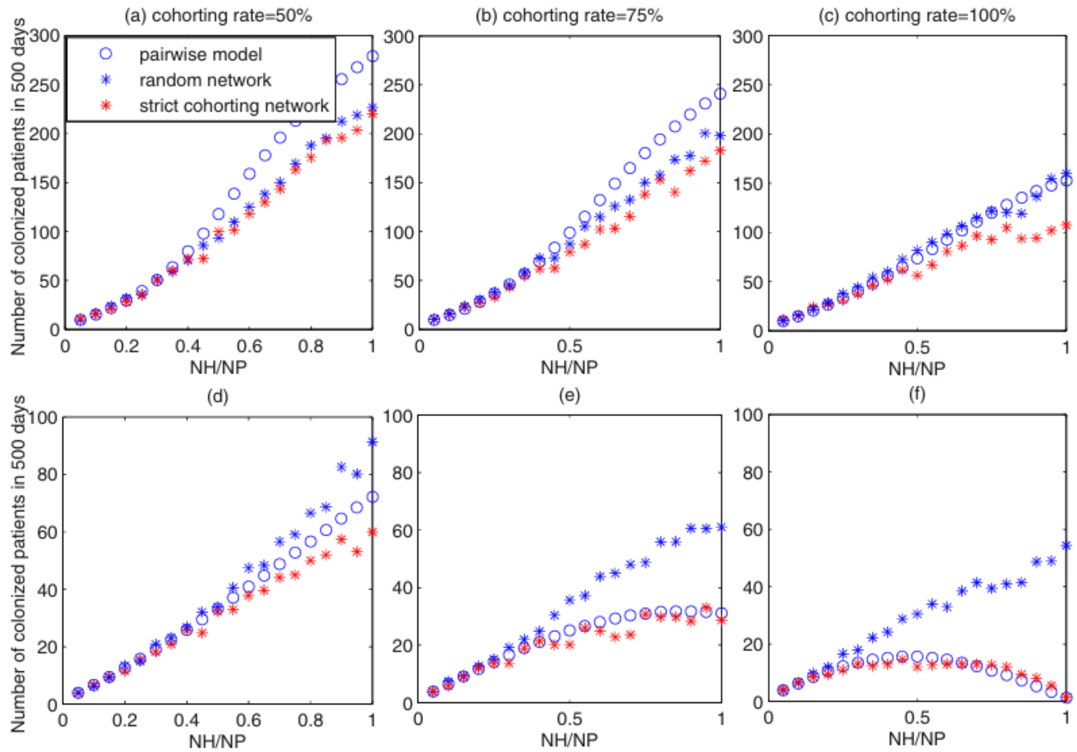

Figure 3 | The average number of colonized patients in a period of 500 days versus the nurse-patient ratio when the cohorting rate was 50% ((a), (d)), 75% ((b), (e)), or 100% ((c), (f)). Figures in the first line (a), (b) and (c) show the results when the indirect transmission rate was 48.9, while those in the second line show the results when the indirect transmission rate was 0. Blue circles show simulation results for the pairwise model. Blue (red) stars show simulation results on the random network (the strict cohorting network). All other parameter values are as listed in Table 1.

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Our results indicate that for clean environments and with strict cohorting, increasing the nurse-patient ratio results in an initial increase and then a decline in MRAB colonization.

For developing more effective control strategies, the findings suggest that increasing the cohorting rate and nurse-patient ratio are effective interventions for relatively clean environments, …

Sci Rep. 2015 Mar 25:5:9478.

Nurse-to-patient ratio and HAIs

Table 3. Association of Nurse Staffing and HAIs (n = 448 826)[a]

Variables	HR (95% CI)	P
RN understaffing[b]		
(0 as reference group)		
1	1.00 (0.92–1.09)	0.98
2	1.15 (1.02–1.30)	0.024
NS understaffing		
(0 as reference group)		
1	1.05 (0.97–1.12)	0.226
2	1.11 (1.01–1.21)	0.031

Abbreviations: 95% CI, 95% confidencel interval; HAI, healthcare associated infection; HR, hazard ratio; NS, nursing supporting staff; RN, registered nurse.

[a]Model is controlled for patient individual risks such as demographics, comorbidity, medical procedures and treatments, unit patient turnover, unit types, and data year.

[b]Understaffing and skill mix are both calculated by comparing with 80% of median in the unit and shift: 0 = neither day nor night shift was understaffed, 1 = 1 of the shifts was understaffed, and 2 = both shifts were understaffed.

J Nurs Adm. 2019 May; 49(5): 260–265.

Setting

- Hospital system with 3 campuses located in a large, metropolitan US city with more than 2000 beds and more than100 000 patient discharges annually.
- Years 2007-2012
- 100 264 Patienten, 4390 HAIs

Statistical analysis

- Multivariable Cox proportional hazard model
- Staffing 2 days prior to HAI onset, treated as time-varying covariate
- Adjustment for unit types, patient turnover, year and patient individual risks

Nurse-to-patient and physician-to-patient ratio: mortality

TABLE 2. Characteristics of Shifts Without Any Death or With At Least One Death

	Shifts Without Death (*n* = 11,251)	Shifts With ≥ 1 Death (*n* = 415)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Patients-to-nurse ratios (%)				
< 1:1	290 (2.6)	5 (1.2)	1	1
1:1–1.5:1	2,748 (24.4)	91 (21.9)	1.6 (0.8–2.9)	1.9 (0.7–4.6)
1.5:1–2:1	5,143 (45.7)	181 (43.7)	1.7 (0.9–3.1)	2.0 (0.8–5.0)
2:1–2.5:1	2,461 (21.9)	103 (24.8)	1.8 (0.9–3.2)	2.3 (0.9–5.8)
> 2.5:1	609 (5.4)	35 (8.4%)	2.2 (1.2–4.3)	3.5 (1.3–9.1)[a]
Patients-to-physician ratios (%)				
< 8	8,144 (72.4)	256 (61.7)	1	1
8:1–10:1	1,391 (12.4)	59 (14.2)	1.0 (0.8–1.3)	0.9 (0.7–1.3)
10:1–14:1	1,408 (12.5)	74 (17.8)	1.0 (0.8–1.3)	1.1 (0.8–1.5)
> 14:1	308 (2.7)	26 (6.3)	1.5 (1.0–2.1)	2.0 (1.3–3.2)[a]
Residents-to-physicians ratio (SD)	0.27 (0.26)	0.26 (0.25)	0.7 (0.4–1.1)	0.9 (0.5–1.5)
Mean patient turnover (SD)[b]	6.8 (9.2)	7.8 (11)	2.3 (1.1–4.7)	5.6 (2.0–15.0)[c]
Mean number of life-sustaining procedure (SD)[d]	1.3 (0.4)	1.4 (0.4)	4.4 (3.5–5.4)	5.9 (4.3–7.9)[c]
Mean proportion of men (SD)	0.6 (0.1)	0.6 (0.1)	1.6 (0.9–2.8)	1.8 (0.8–3.8)
Mean proportion of surgical cases (SD)	0.6 (0.3)	0.6 (0.3)	0.6 (0.4–1.0)	0.5 (0.2–1.1)
Mean Simplified Acute Physiology Score II[e] (SD)	50 (11)	52 (11)	1.5 (1.4–1.7)	1.5 (1.3–1.7)[c]
Mean number of comorbidities (SD)[f]	2.2 (0.6)	2.3 (0.6)	1.1 (0.9–1.3)	0.9 (0.8–1.1)

Setting

- Multicenter longitudinal in eight adult ICUs in France
- 1-year period with 5718 patients, 11666 shifts
- 851 (15%) deaths

Statistical analysis

- multilevel Poisson regression taking into account the clustering effect of patients within the ICU
- final multivariate model included the following variables: P/N, P/P and residents-to-physicians ratios, patient turnover, number of LSP, proportion of men, proportion of surgical cases, SAPSII, and number of comorbidities

Crit Care Med. 2015 Aug;43(8):1587-94.

Take home messages

- Direct and indirect transmission matters

- Predominantly propagated outbreaks?
  - But you can introduce it into the environment (water-bearing devices, sinks,…)

- Risk of *A. baumannii* carriage differs by country/regions
  - Awareness for potential carriage among repatriated patients

- Multifaceted approach for control needed
  - Education
  - Hand hygiene, standard precautions
  - Contact isolation
  - Environmental disinfection
  - Nurse to patient ratio matters
  - Screening for early identification of colonized patients

Thanks for your attention!

Peter Schreiber

peterwerner.schreiber@usz.ch

JUNE

2 ... IPAC Considerations in Global Emergencies *(Broadcast live from the IPAC Canada conference)*
With Dr. Bois Marufov, Canada

3 ... Persuasive Conversations *(Broadcast live from the IPAC Canada conference)*
With Ryan Mullen, Canada

19 ... Carbapenem Resistant *A. baumabnii*
With Prof. Peter Werner Schreiber, Switzerland

26 ... Do We Still Need to Talk About Antibiotic Resistance
With Prof. Jean-Paul Zahar, UK

JULY

10 ... Challenges to Maintaining Asepsis in Patient Care Settings Beyond the Operating Department
With Prof. Dinah Gould, UK

22 ... Proposal for a Screening Protocol for *Candida auris* Colonization
Afro-European Teleclass
With Juliette Severin, Netherlands

24 ... Empowering Nurses in Antimicrobial Stewardship (an IFIC teleclass)
Afro-European Teleclass
With Prof. Maria Clara Padoveze, Brazil, and Dr. Enrique Castro-Sánchez, UK

AUGUST

7 ... How Do Perceptions of Hygiene and Cleanliness Influence Infection Prevention Behaviours in Our Homes and Everyday Lives, and in Healthcare Settings?
With Dr. Sally Bloomfield, UK

12 ... Barriers to Implementing IPC Programs in Low Resource Settings and How to Overcome Them
With Prof. Shaheen Mehtar, South Africa

20 ... Insertion and Maintenance of Bundles for Peripheral IVs
Australasian Teleclass
With Dr Gillian Ray-Barruel, Australia

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