# Air contamination in the hospital environment

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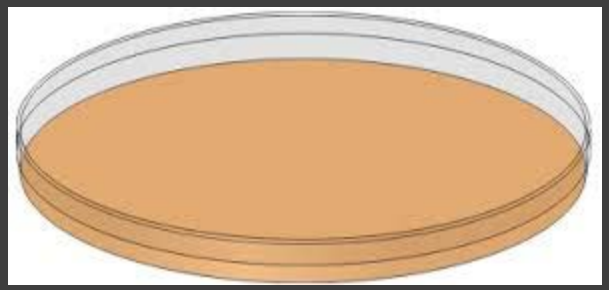
# Disclosures

- Speaker: Xenex, Ecolab
- Consultant: Xenex, Clorox

- Brief review of the literature
- My personal experience
- Some insights into why this happened

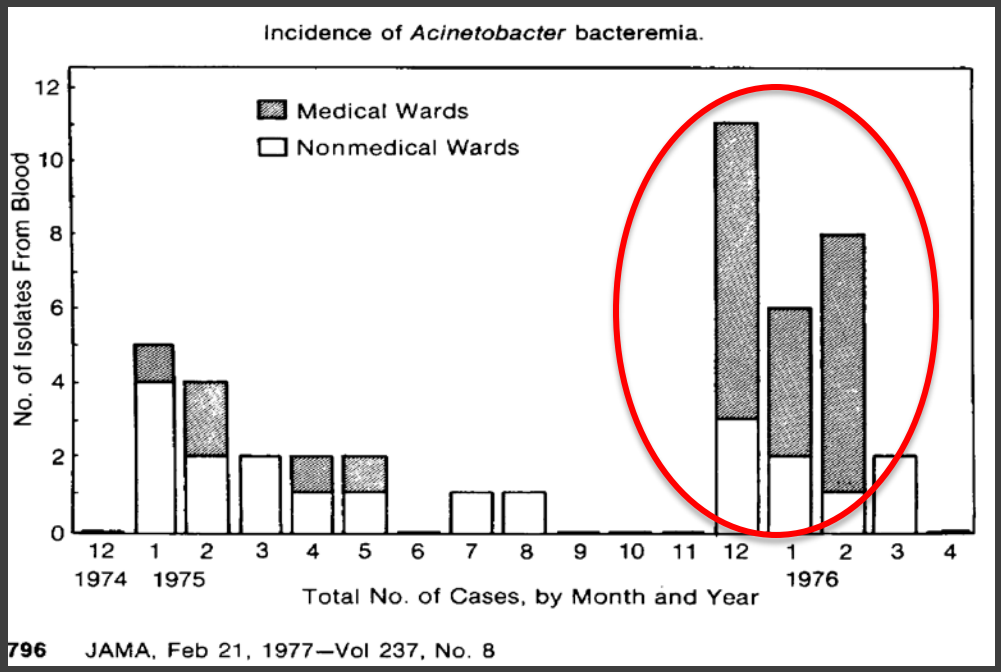
**THERE ARE TWO METHODS TO MEASURE AIR CONTAMINATION:**

**Passive:**



**Active:**

- Univ. of Iowa
- 24 patients acquired *A. calcoaceticus* in 4 months
- Retrospective review showed that almost all cases were using a room humidifier at the bedside




Smith & Massanari. JAMA, 1977

Decontamination of humidifiers has been very difficult to achieve.[1] Hospitals must be aware of the potential dangers of cold-air humidifiers in an inpatient setting, and serious consideration should be given to the abandonment of these devices.

| | | | |
|---|---|---|---|
| 0.3 | Solid growth | Solid growth | Solid growth |
| 1.0 | 30 | 320 | 1,300 |
| 2.0 | 25 | 240 | 700 |

Smith & Massanari. JAMA, 1977

*Journal of Hospital Infection* (1987) **9**, 110–119

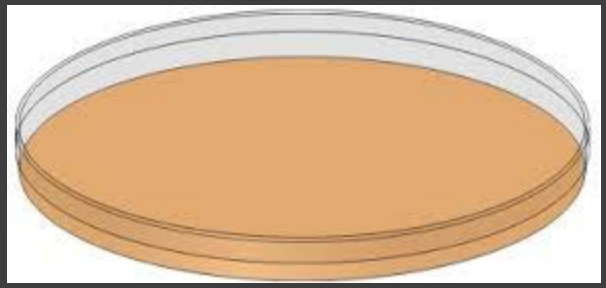
# Hospital outbreak of multi-resistant *Acinetobacter anitratus*: an airborne mode of spread?

**Karen D. Allen and Helen T. Green**

*Department of Microbiology, Walton Hospital, Rice Lane, Liverpool L9 1AE*

*Accepted for publication 14 March 1986*

**Summary:** During a 10-month period, from October 1984 to July 1985, a multi-resistant strain of *Acinetobacter anitratus* was isolated from 36 patients in three neurosurgical wards, one medical ward and the intensive care unit of a district general hospital, and from two patients in the intensive care unit of a hospital in another district. Fourteen patients developed significant infection including pneumonia (10), meningitis (2), septicaemia (2) and wound infec-



- 16 (20%) out of 82 settle plates were positive for Acinetobacter
- Within 3 meters of three colonized patients

Allen & Green. JHI, 1987

JOURNAL OF CLINICAL MICROBIOLOGY, Jan. 2001, p. 228–234 Vol. 39, No. 1
0095-1137/01/$04.00+0 DOI: 10.1128/JCM.39.1.228–234.2001


# Epidemiology and Infection Control Implications of *Acinetobacter* spp. in Hong Kong

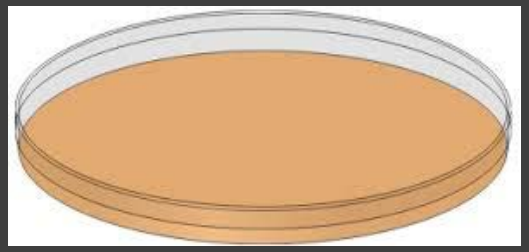
ELIZABETH T. S. HOUANG,[1]* Y. W. CHU,[1] C. M. LEUNG,[1] K. Y. CHU,[1] J. BERLAU,[2] K. C. NG,[1] AND A. F. B. CHENG[1]

*Department of Microbiology, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin NT, Hong Kong SAR, People's Republic of China,[1] and Department of Ophthalmology, University of Rostock, 18057 Rostock, Germany[2]*

Received 30 March 2000/Returned for modification 12 September 2000/Accepted 17 October 2000

**In a previous study, we showed that *Acinetobacter* genomic DNA group 3 was the most common species among blood culture isolates and was commonly found on superficial carriage sites of the healthy and the sick, which**

Houang et al. JCM 2001



- 10 settle plates for 6 hours each on seven weekly occasions in ICU
- 67 (96%) yielded Acinetobacter (1-15 colonies per plate)
- <5 colonies/plate: 32% of plates
- 5-15 colonies: 53% of plates
- >15 colonies: 15% of plates

Houang et al. JCM 2001

*Journal of Hospital Infection* (2002) **50**: 30–35
doi:10.1053/jhin.2001.1136, available online at http://www.idealibrary.com on IDEAL®

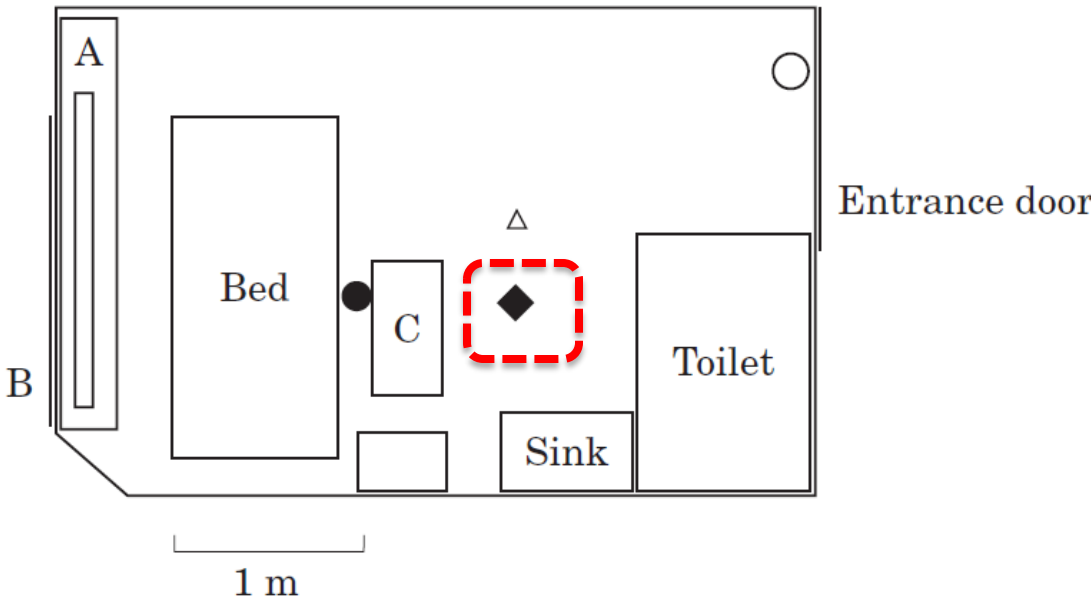
# Evaluation of bedmaking-related airborne and surface methicillin-resistant *Staphylococcus aureus* contamination

T. Shiomori*, H. Miyamoto†, K. Makishima*, M. Yoshida*, T. Fujiyoshi*, T. Udaka*, T. Inaba* and N. Hiraki*

**Table I** *Characteristics of patients with MRSA infection or colonization*

| Patient no. | Sex/ age (years) | Underlying disease | Infection | Nasal carriage |
|---|---|---|---|---|
| 1 | M/70 | Parapharyngeal Ca[1] | Pneumonia | Positive |
| 2 | M/73 | Hypopharynx Ca[1] | Pneumonia | Positive |
| 3 | M/67 | Acute renal failure | Pneumonia | Negative |
| 4 | F/69 | DCM[2] | Pneumonia | Positive |
| 5 | F/75 | Lung Ca[1] | Pneumonia | Positive |
| 6 | F/8 | Cerebral palsy | Pneumonia | Positive |
| 7 | M/9 | WH disease[3] | Pneumonia | Negative |
| 8 | M/5 | HE[4] | Pneumonia | Positive |
| 9 | M/71 | Oesophageal Ca[1] | Wound | Positive |
| 10 | M/65 | Skin Ca[1] | Wound | Negative |
| 11 | F/52 | Tongue Ca[1] | Colonization | Positive |
| 12 | M/56 | Diabetes | Colonization | Positive |
| 13 | F/64 | Larynx Ca[1] | Colonization | Positive |

[1]Ca: cartinoma; [2]DCM: dilated cardiomyopathy;
[3]WH disease: Werdnig–Hoffmann disease;
[4]HE: Hypoxic encephalopathy.



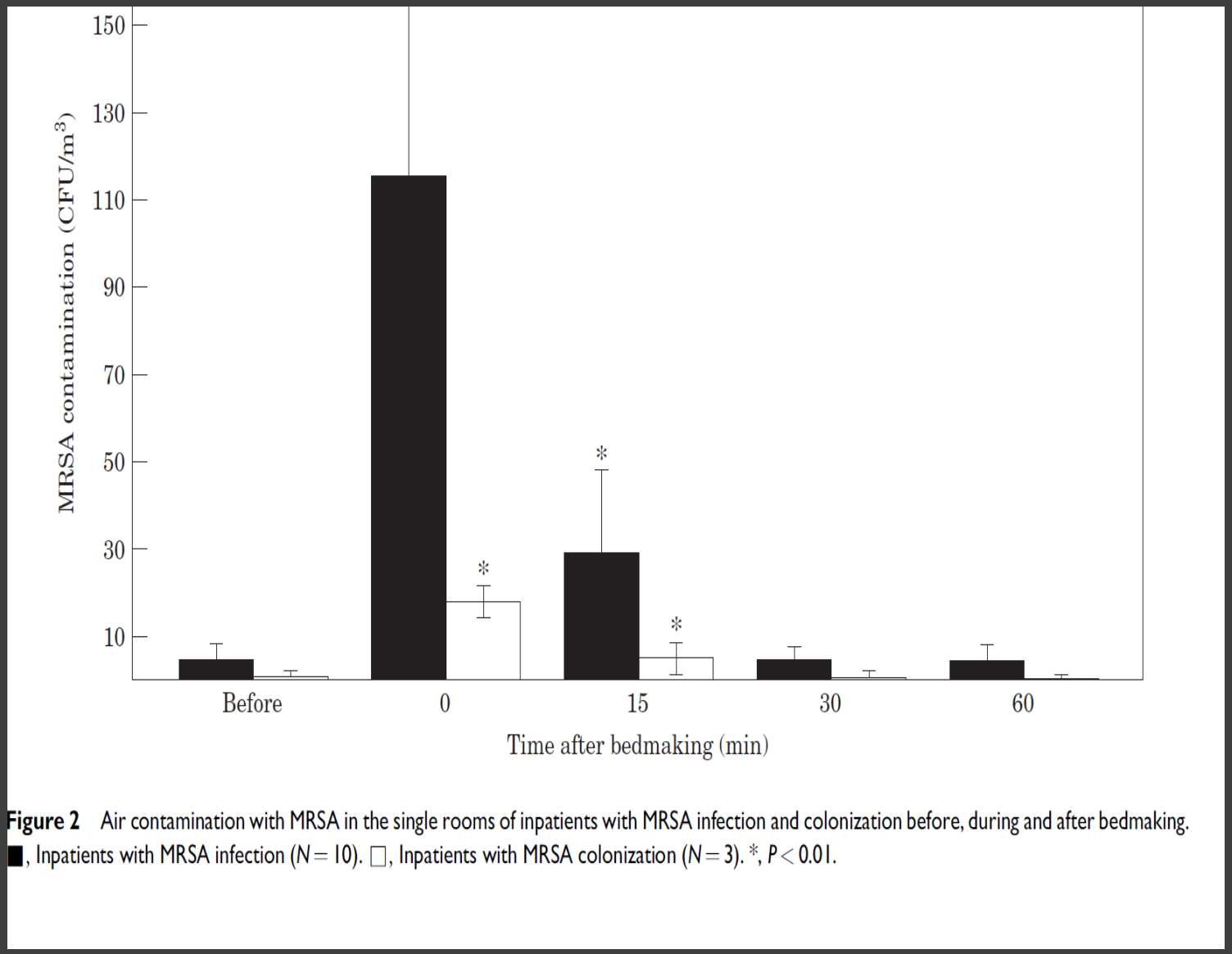



**Figure 2** Air contamination with MRSA in the single rooms of inpatients with MRSA infection and colonization before, during and after bedmaking. ■, Inpatients with MRSA infection ($N = 10$). □, Inpatients with MRSA colonization ($N = 3$). *, $P < 0.01$.

Shiomori et al. JHI, 2002

BURNS 40 (2014) 295–299

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/burns


# Antibiotic resistance and OXA-type carbapenemases-encoding genes in airborne *Acinetobacter baumannii* isolated from burn wards

*Jing Gao*[a,b,1], *Xiaonan Zhao*[a,1], *Ying Bao*[b], *Ruihua Ma*[c], *Yufa Zhou*[d], *Xinxian Li*[a,b,c,d], *Tongjie Chai*[a,*], *Yumei Cai*[a,*]

[a] *College of Animal Science and Veterinary Medicine, Shandong Agricultural University, China, Sino-German Cooperative Research Centre for Zoonosis of Animal Origin Shandong Province, Tai'an Shandong, China*
[b] *Tai'an City Central Hospital, Tai'an, China*
[c] *Affiliated Hospital of the Shandong Agricultural University, Tai'an, China*
[d] *Daiyue Husbandry Bureau of Tai'an, Tai'an, China*

Gao et al. Burns, 2014

- Impactor
- 10 minutes
- 1.5 meters from the floor (near headboard)
- Burn ICU
- 6 months

Gao et al. Burns, 2014

16 ambient air samples were positive
15 were imipenem resistant
15 isolates were OXA 23

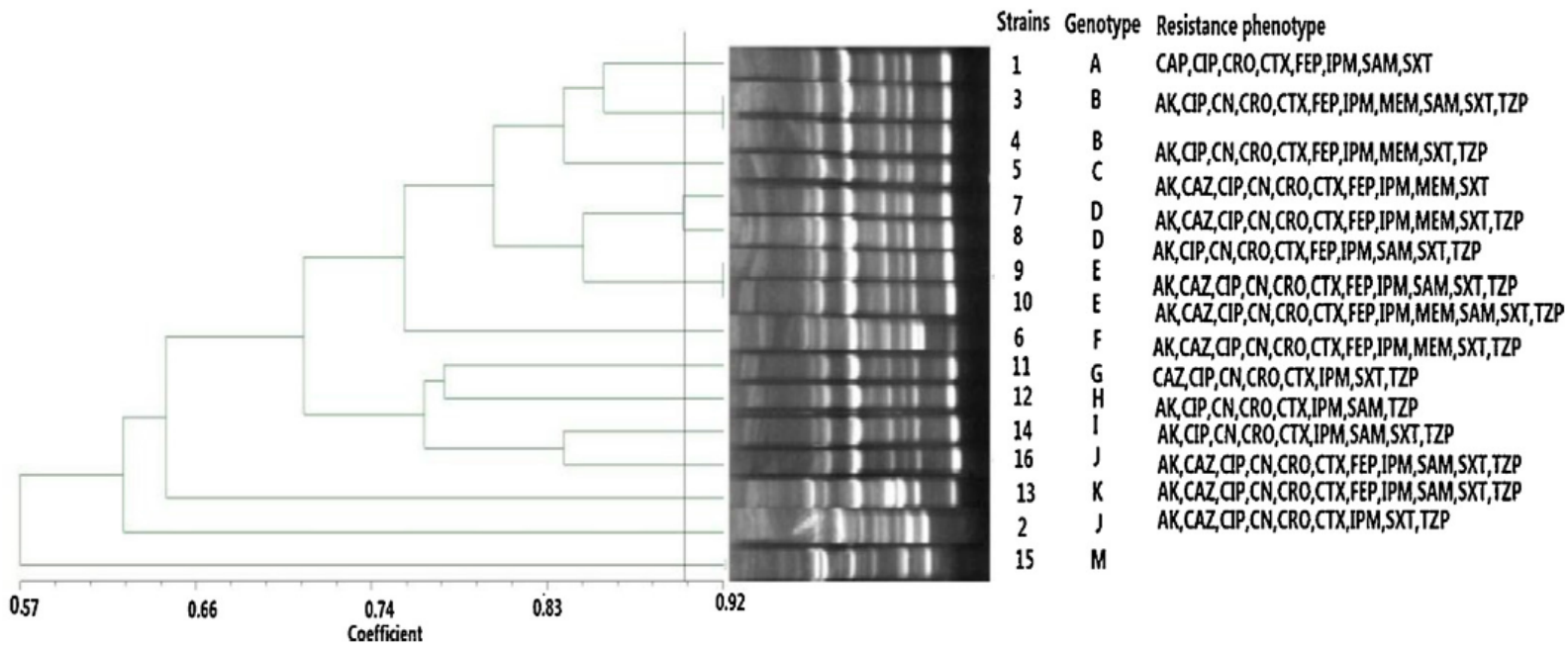



**Fig. 2 – Dendrogram of the airborne *A. baumannii* isolated from burn wards by REP-PCR.**

Gao et al. Burns, 2014

July 2009

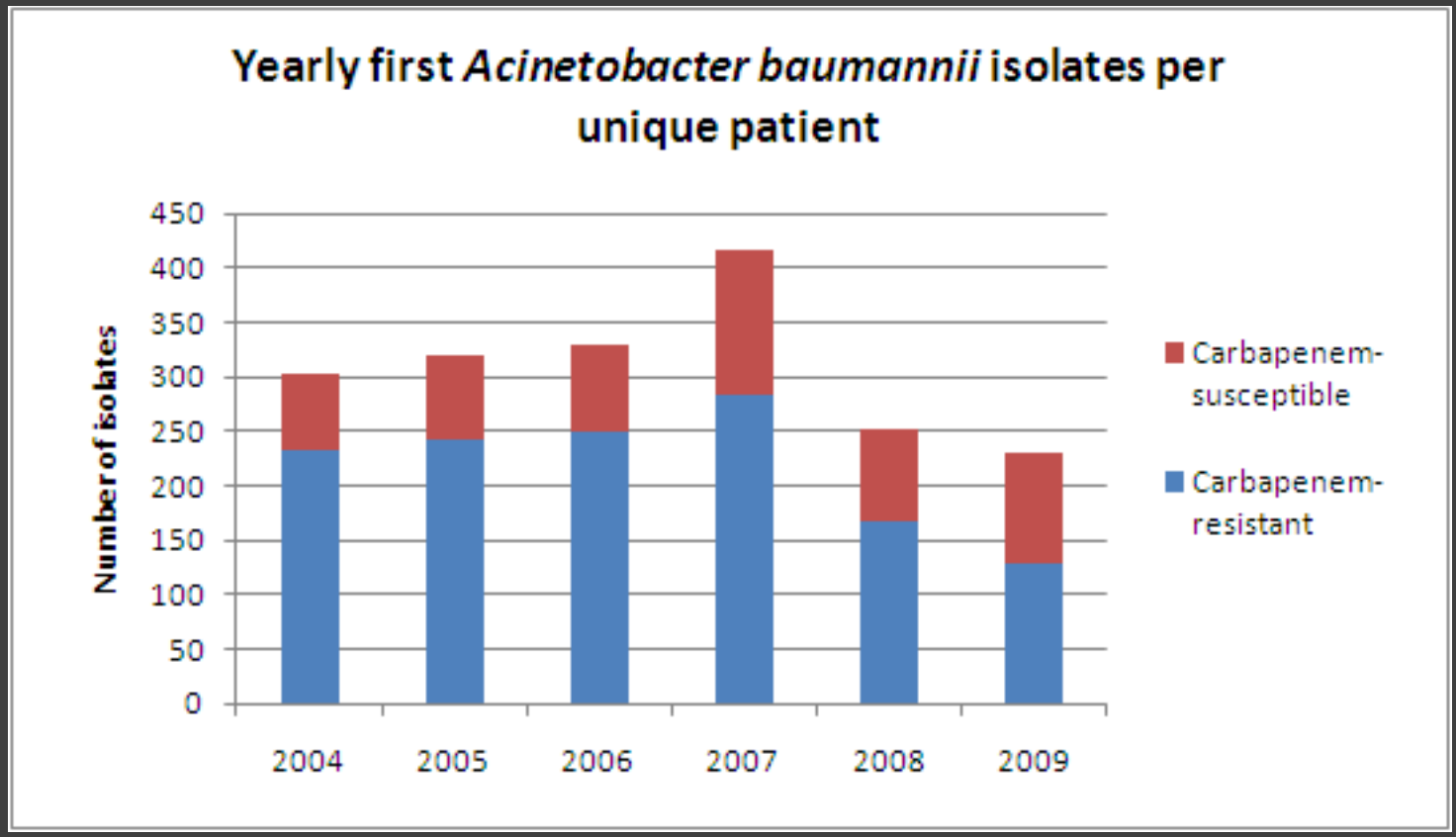
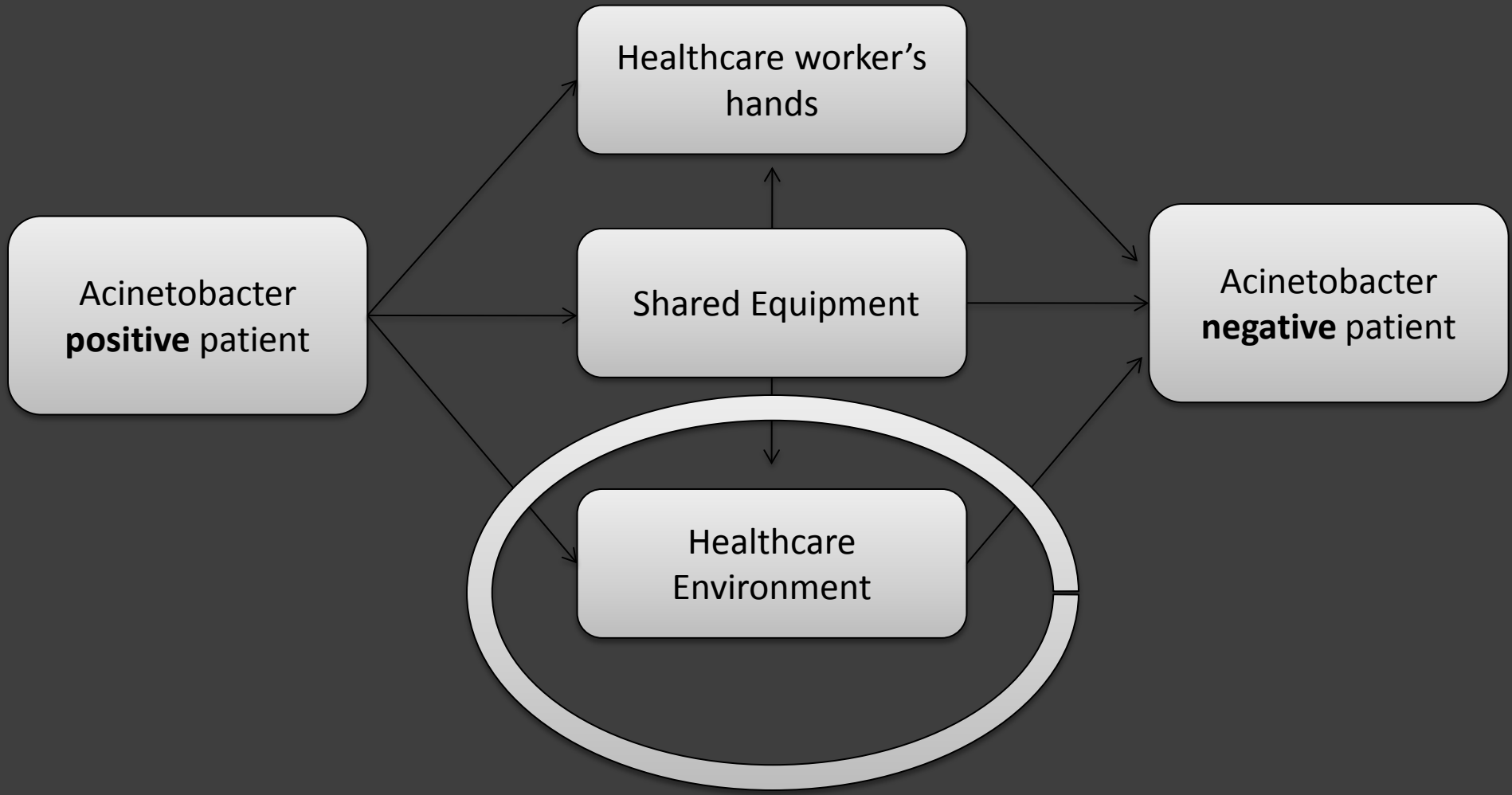



Figure based on the Infection Control Department's electronic database


Healthcare worker's hands
Acinetobacter **positive** patient
Shared Equipment
Acinetobacter **negative** patient
Healthcare Environment

# Aerosolization of *Acinetobacter baumannii* in a Trauma ICU*

L. Silvia Munoz-Price, MD[1,2,4]; Yovanit Fajardo-Aquino, MD[4]; Kristopher L. Arheart, EdD[2,5]; Timothy Cleary, PhD[6]; Dennise DePascale, MT[4]; Louis Pizano, MD[3]; Nicholas Namias, MD[3]; Jesabel I. Rivera, BS[7]; Jessica A. O'Hara, MPH[7]; Yohei Doi, MD, PhD[7]

**Objective:** To establish the presence of air contamination with *Acinetobacter baumannii* in the trauma ICU.
**Design:** Point prevalence microbiological surveillances.
**Settings:** A 1,500-bed public teaching hospital in the Miami metro area.
**Patients:** Trauma ICU patients.
**Measurements:** Pulsed field electrophoresis was performed on

**Conclusions:** Aerosolization *of A. baumannii* in the ICUs is a concern, and its role in the transmission of this organism among patients should be further clarified. (*Crit Care Med* 2013; 41:1915–1918)
**Key Words:** *Acinetobacter* species; air contamination; ICU

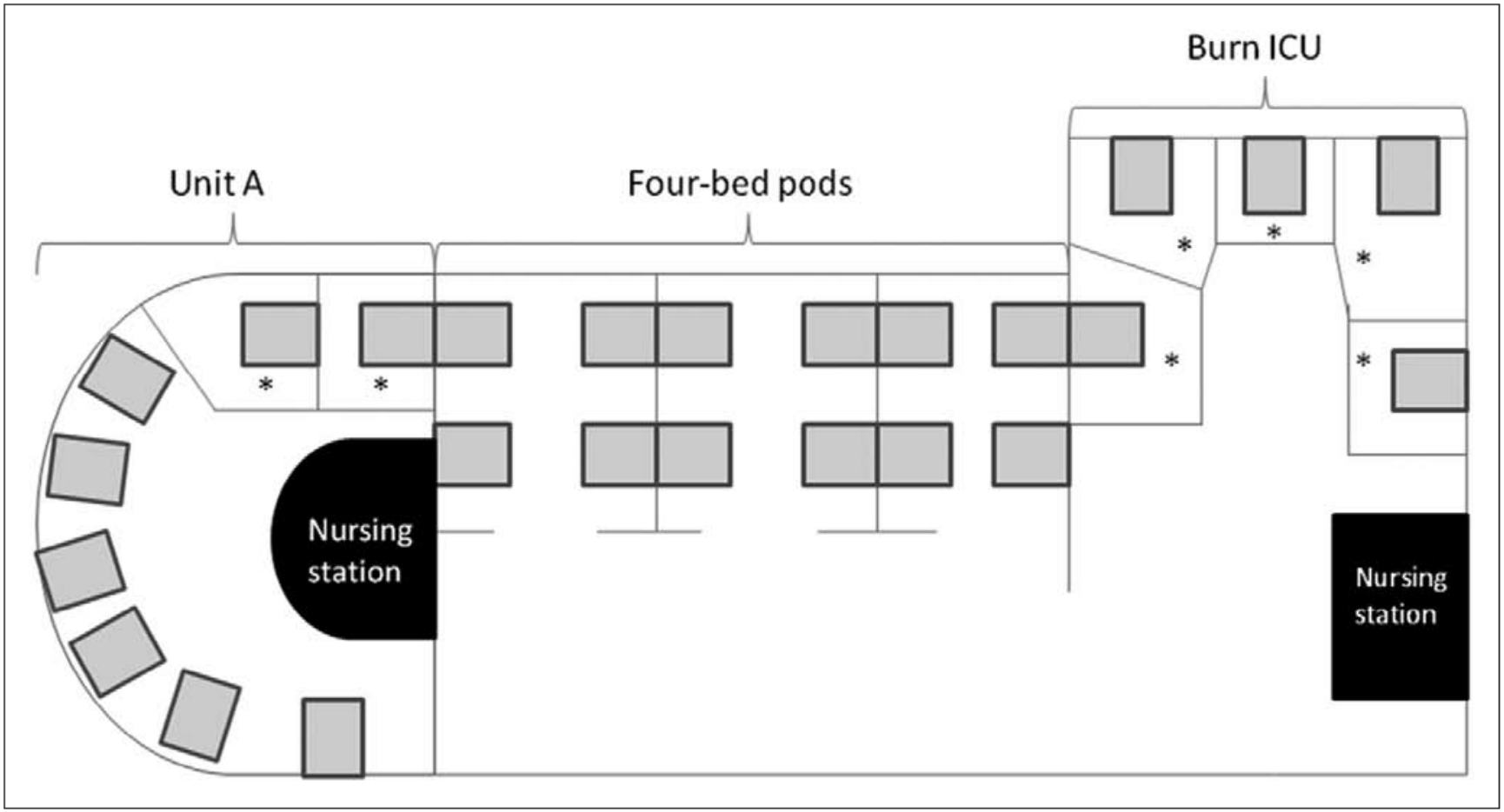



**Figure 1.** Cartoon of the layout of the trauma-burn ICU (TICU). Unit A has eight beds, out of which two (*) are individual rooms. All five rooms (*) in TICU are individual rooms. All other beds are located in open pods.


Orbiter
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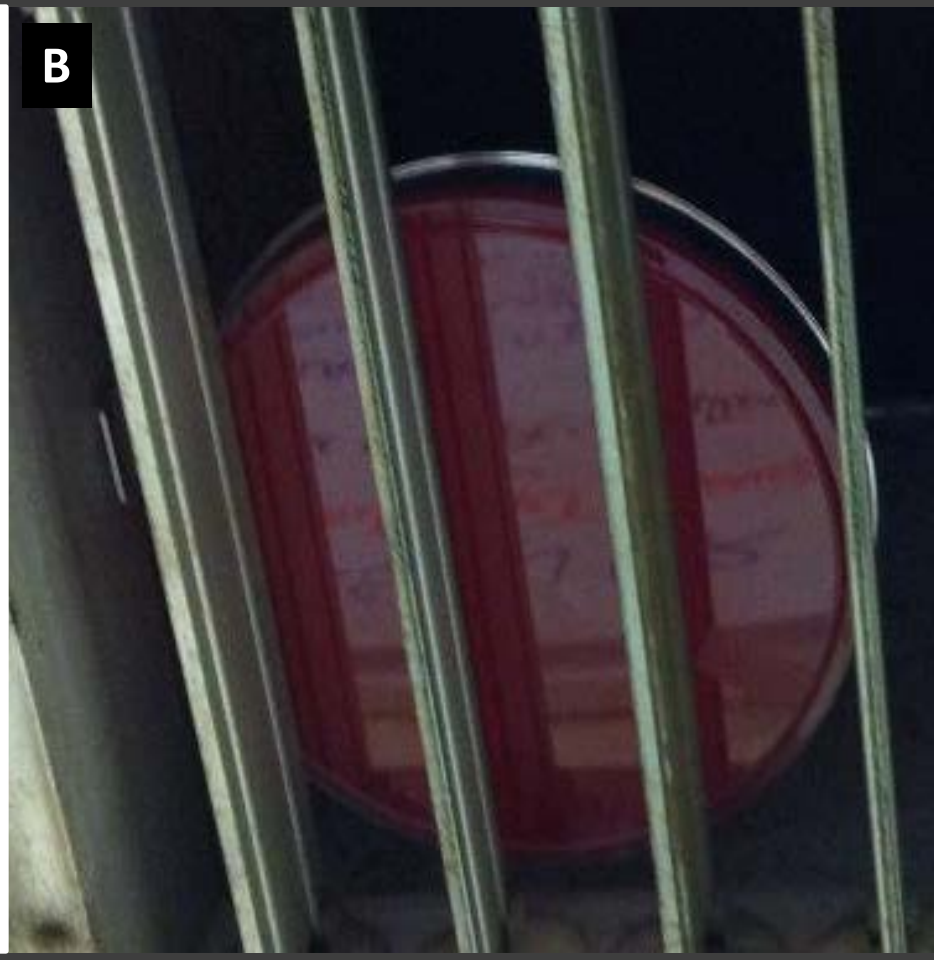
Giving Excellent Care
04-0212
Casey


A


B

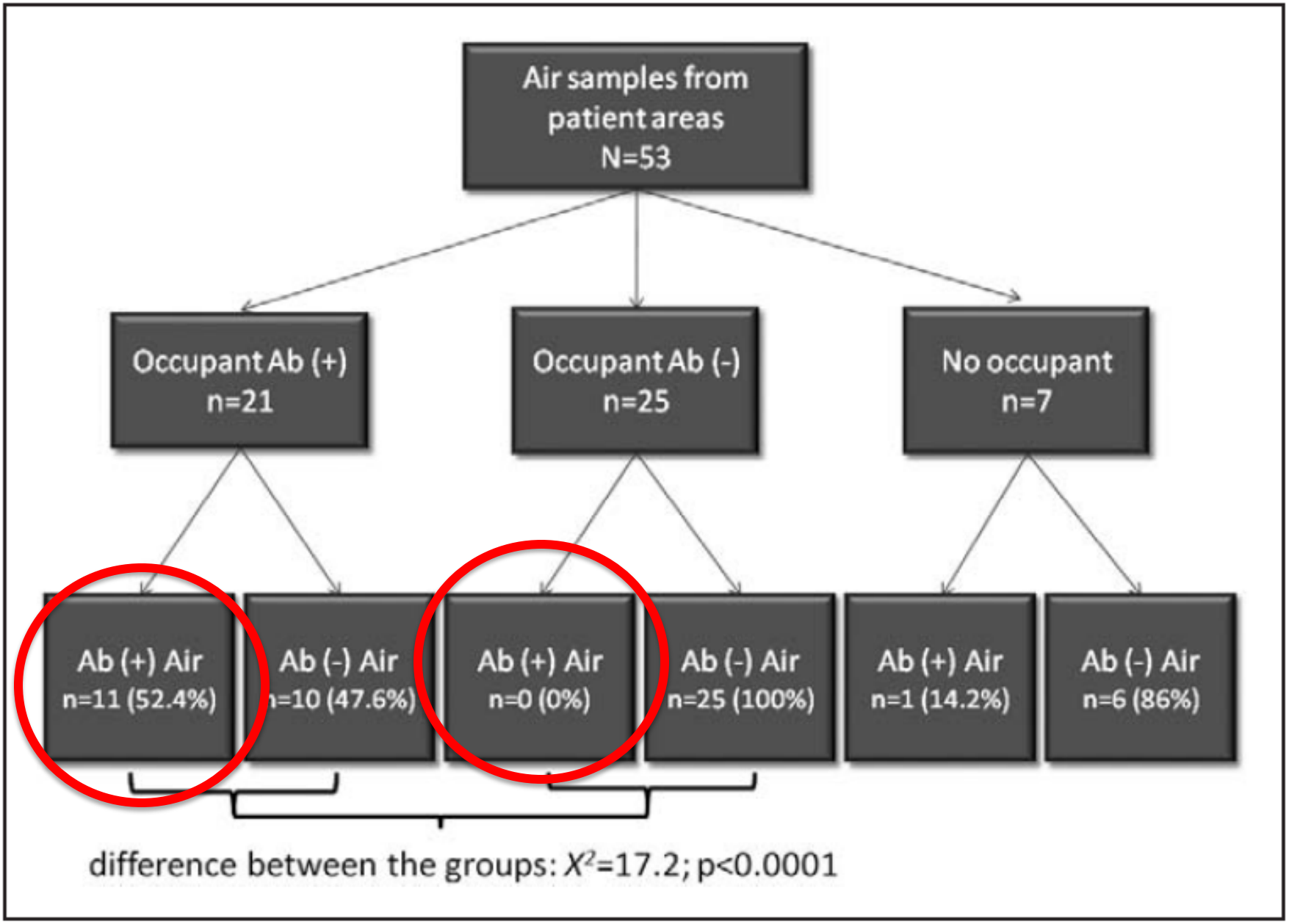



**Figure 2.** Results of air cultures based on room occupant status. Ab = *Acinetobacter baumannii*.

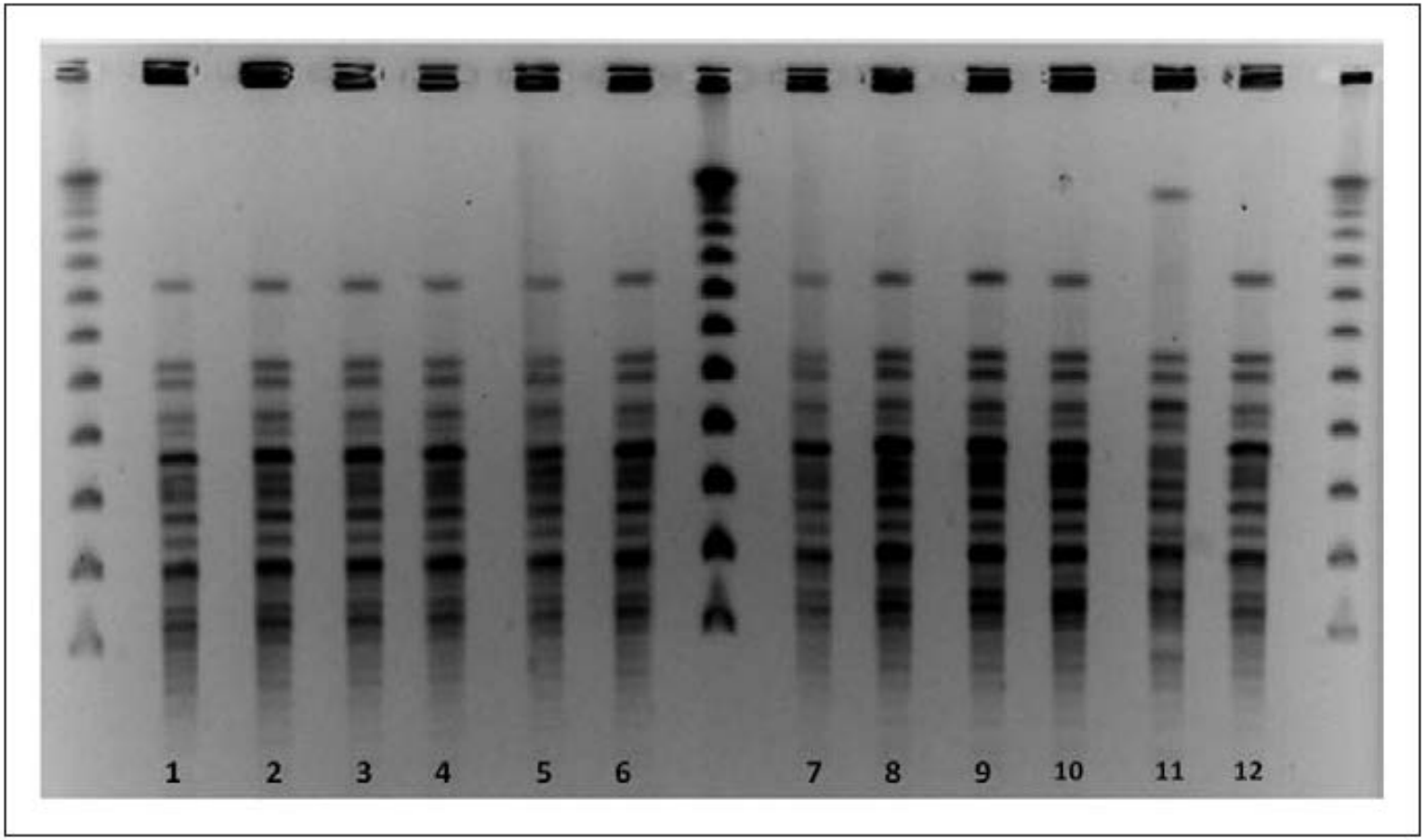
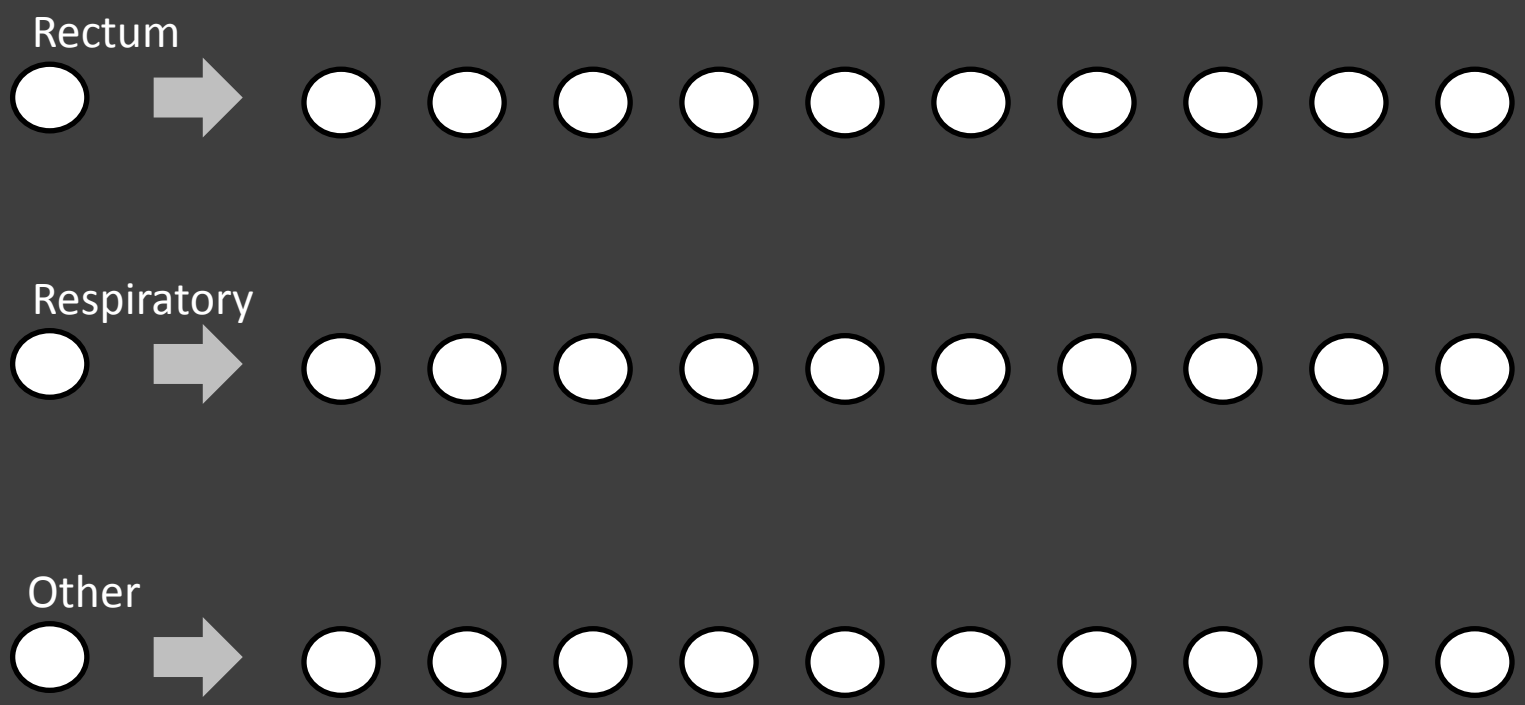


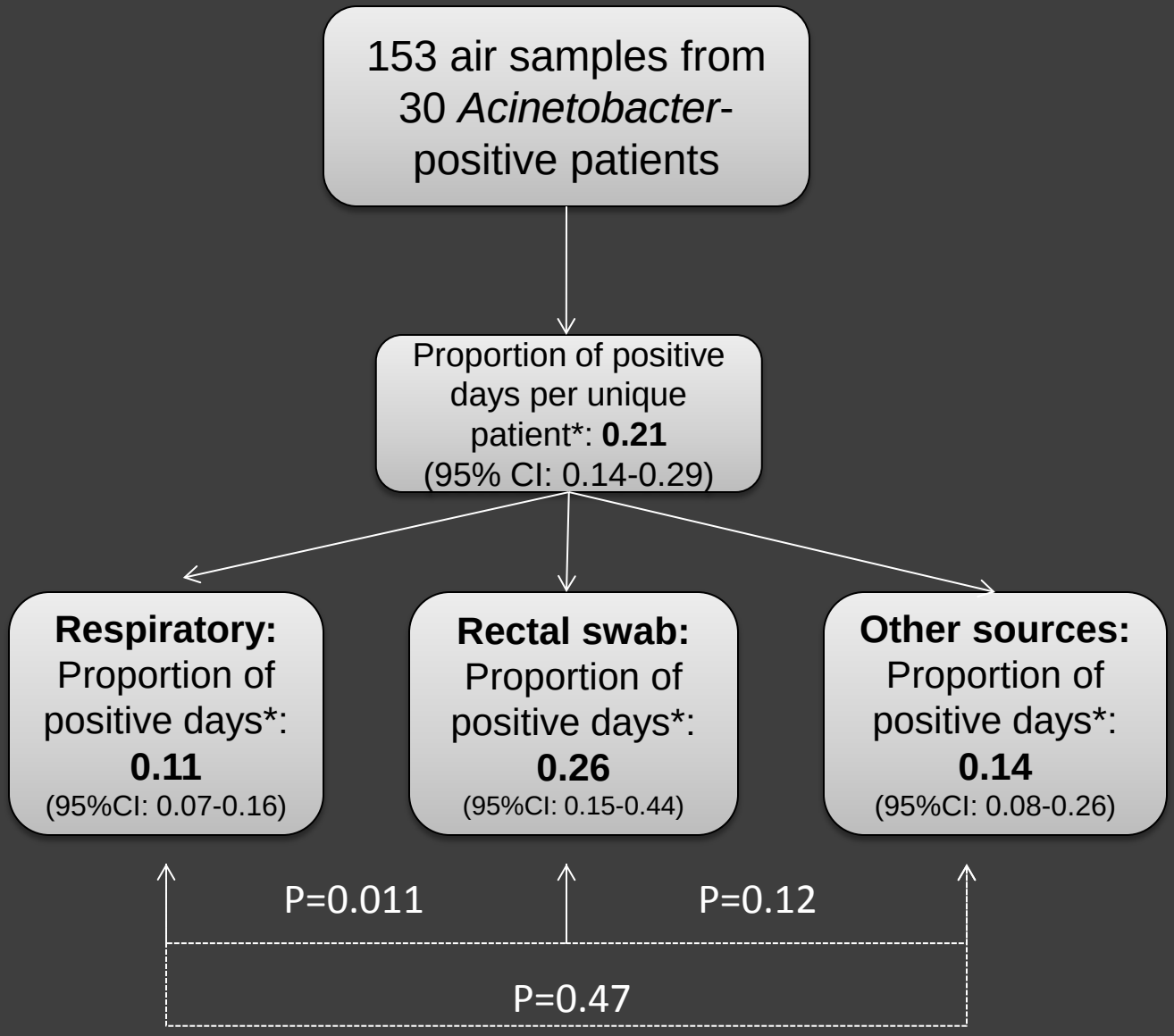

**Figure 3.** Pulse field gel electrophoresis on air and clinical isolates. (1–9) Environmental *Acinetobacter baumannii* isolates; all from air samples except for line 3 that corresponds to the isolate obtained after swabbing an intake air duct. (10–12) carbapenem-resistant *A. baumannii* clinical isolates from patients present in the unit on the day air cultures were performed. Isolates 7, 8, and 9 corresponded to the air of the patients with clinical isolates 10, 11, and 12, respectively.

JCM
Journals.ASM.org

# Contamination of Ambient Air with *Acinetobacter baumannii* on Consecutive Inpatient Days

Luis A. Shimose,[a] Yohei Doi,[b] Robert A. Bonomo,[c,d] Dennise De Pascale,[i] Roberto A. Viau,[j] Timothy Cleary,[e] Nicholas Namias,[f] Daniel H. Kett,[a] L. Silvia Munoz-Price[g,h]






**RR $_{(+)\text{air cultures I rectal colonization}}$ = 2.35 (95% CI: 1.28-4.34; p=0.006)**

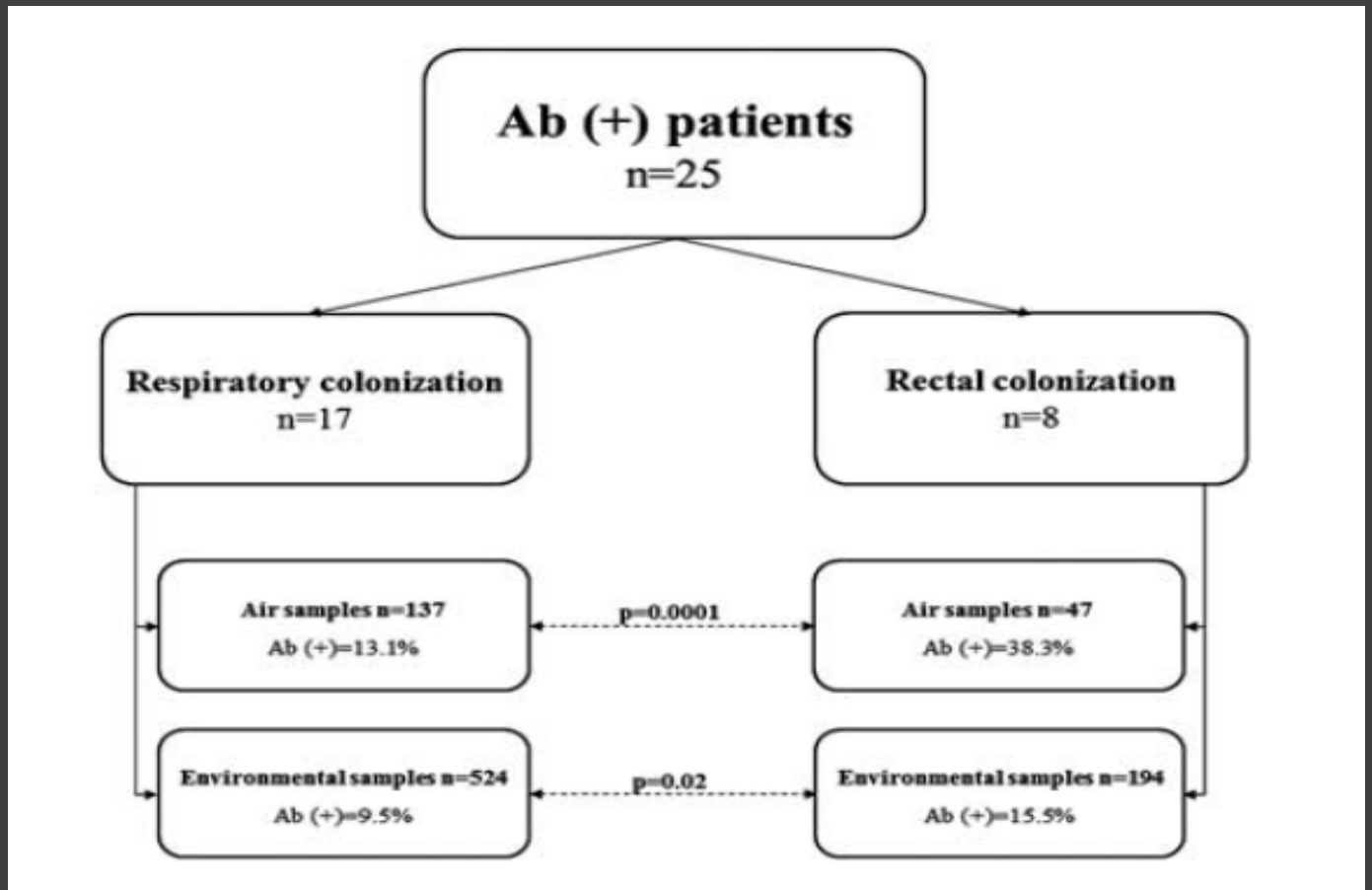
Shimose L, et al. JCM, 2015

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY

ORIGINAL ARTICLE

# Carbapenem-Resistant *Acinetobacter baumannii*: Concomitant Contamination of Air and Environmental Surfaces

Luis A. Shimose, MD;[1] Eriko Masuda, MD;[2] Maroun Sfeir, MD;[3] Ana Berbel Caban, MD;[1] Maria X. Bueno, MD;[1] Dennise dePascale, MT;[4] Caressa N. Spychala, BS;[5] Timothy Cleary, PhD;[4] Nicholas Namias, MD;[6] Daniel H. Kett, MD;[1] Yohei Doi, MD, PhD;[5] L. Silvia Munoz-Price, MD, PhD[7]



## Carbapenem-resistant Enterobacteriaceae: concomitant contamination of air and environmental surfaces

| | Rectal | | Respiratory | | Other | |
|---|---|---|---|---|---|---|
| | N° Days Cultured | N° Days KPC+ | N° Days Cultured | N° Days KPC+ | N° Days Cultured | N° Days KPC+ |
| **Total Env** | 248 | 12 (4.8%) | 101 | 1 (0.99%) | 163 | 5 (3%) |
| **Bed** | 70 | 5 (7.1%) | 28 | 1 (3.6%) | 43 | 4 (7%) |
| **Table** | 69 | 3 (4.3%) | 28 | 0 (0%) | 42 | 1 (2.4%) |
| **IV Pump** | 56 | 4 (7.1%) | 25 | 0 (0%) | 37 | 1 (5.4%) |
| **Ventilator** | 53 | 0 (0%) | 20 | 0 (0%) | 41 | 0 (0%) |
| **Air** | 69 | 3 (4.3%) | 23 | 1 (4.3%) | 42 | 4 (9.5%) |

Under review; 2016

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY

CONCISE COMMUNICATION

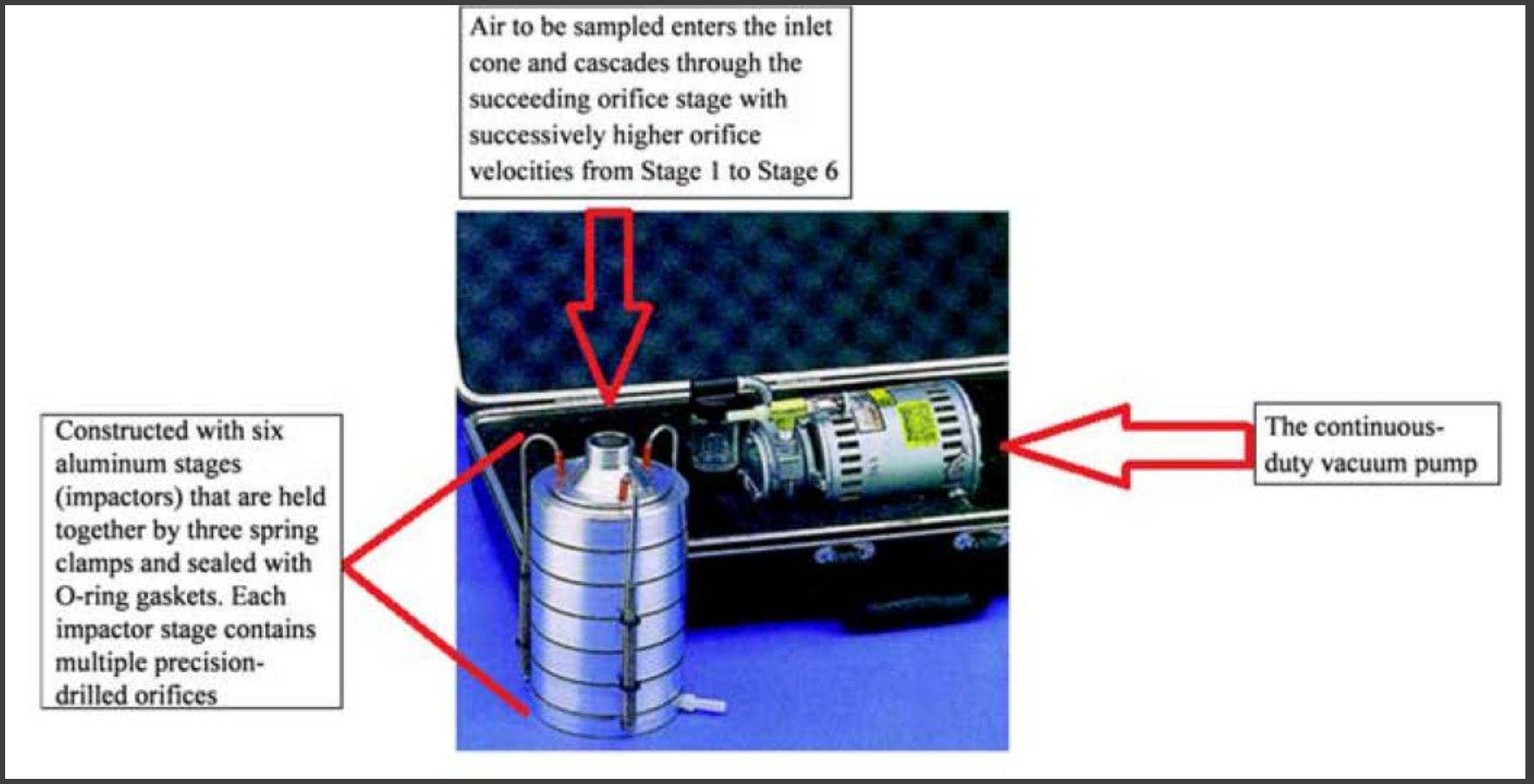
# Infrequent Air Contamination With *Acinetobacter baumannii* of Air Surrounding Known Colonized or Infected Patients

Clare Rock, MD, MS;[1] Anthony D. Harris, MD, MPH;[1] J. Kristie Johnson, PhD;[2] Werner E. Bischoff, MD, PhD;[3] Kerri A. Thom, MD, MS[1]

is stable during the first hour of air sampling, which makes conditions ideal for survival of viable bacteria.[5] After that period there is a potential for drying of the agar plate, which may result in difficulty culturing the bacteria. The impaction method is designed to separate particles from air flow and embed them onto an agar surface. The Six-Stage Viable Andersen Cascade Impactor has a vacuum pump that draws air at a speed of 28.3 liters/minute through 6 layers of agar plates, each layer composed of orifices of decreasing diameter, representing the human respiratory tract (Figure 1). All air sampling was performed between the hours of 9 AM and 5



Rock C, et al. ICHE 2015




Rock C, et al. ICHE 2015

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY JULY 2015, VOL. 36, NO. 7

COMMENTARY

# *Acinetobacter* in the Air: Did Maryland Get It Wrong?

L. Silvia Munoz-Price, MD, PhD

(See the article by Rock et al, on pages 830-832.)

In this issue of *Infection Control & Hospital Epidemiology*, Rock and colleagues[1] present their experience culturing the air of patients colonized or infected with *Acinetobacter baumannii*. The authors used an air impactor in order to culture the ambient air of 12 patient rooms. They found only 1 patient with *A. baumannii* present in ambient air. This is in contrast to what has been previously identified elsewhere.[2–4]

Energy Information Administration,[8] an American hospital's square foot electrical cost is approximately $2.84 per year, of which ventilation and cooling correspond to 30% (approximately $1 per year per square foot). Even though these costs do not seem to be increasing in the nation as a whole, certain regions of the country have observed rising electrical costs, such as Alaska, Florida, California, the Southwest, and the Gulf Coast.[9] From this list, it would seem intuitive that warmer

Munoz-Price LS. ICHE 2015

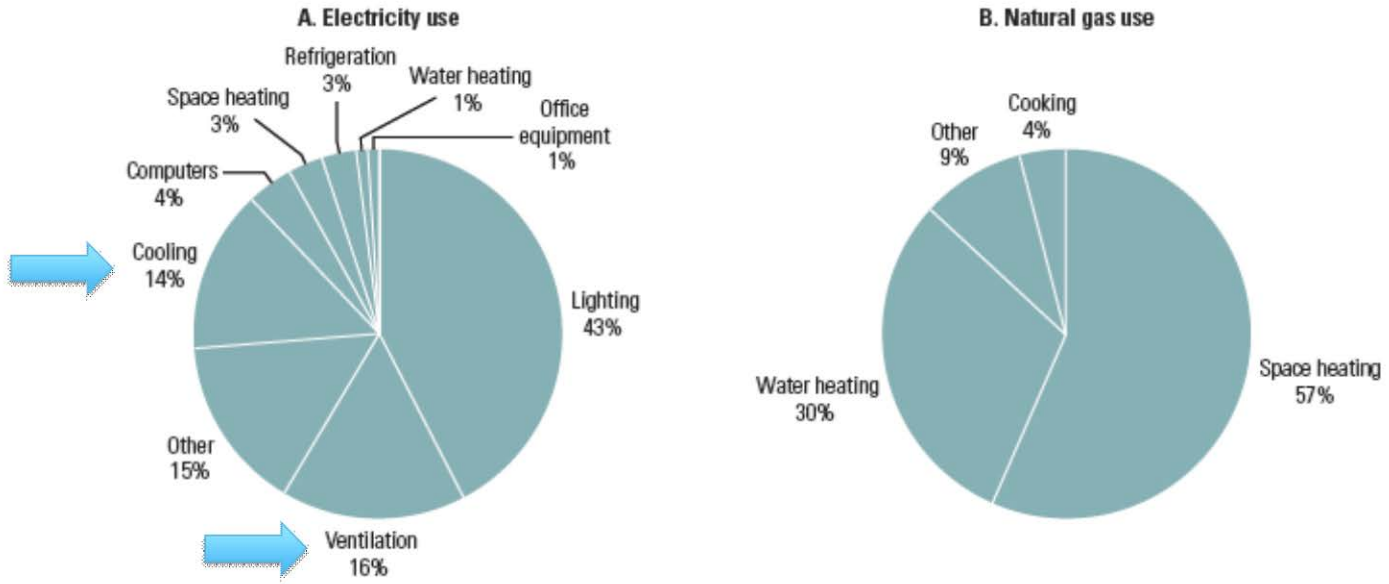
# HVAC Energy Cost in Hospitals US

*2,034 Acute Care Facilities -1.96B Floor Space - $1.88B for HVAC*

***Average electricity spend is $2.84/sqf* – HVAC spend is 30% ($0.95/sqf)***

Figure 1: Healthcare energy consumption by end use in the U.S.

Data from the U.S. Energy Information Administration show that cooling, lighting, and ventilation account for 72 percent of electricity use (A), and space heating dominates natural gas use at 57 percent (B).






* Based on average 10 cents/kWh

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- Most facility directors do not make the connection between poor HVAC operation/maintenance and the higher risk of HAI.
- Directors are under cost pressure and the following most common shortcuts:
  - No coil cleaning
  - Reconditioning air rather than exhausting it
  - Lack of monitoring of proper ventilation functions
  - Purchase of poor quality filters
  - No best practice to check for air-leaks

# Hospital Air-Handler Shutdown Increases Airborne Viable Particle Counts

Patricia L. Harris, M.S.N., R.N., Paul Wiser B.S.N., Diana Toy B.S.N., Shelia Cloud-Woods, M.S.N., R.N., Charles Jennings, Cornelius J. Clancy M.D., Brooke K. Decker, M.D.

[1]Infectious Diseases Section, VA Pittsburgh Healthcare System, Pittsburgh, Pennsylvania, [2]Department of Infectious Diseases, University of Pittsburgh, Pittsburgh, PA, [3]VA Pittsburgh Healthcare System, Pittsburgh, PA.

Correspondence: Brooke Decker, University Drive C 111E-U, Pittsburgh, PA 15240, brooke.decker@va.gov

## Background

- Healthcare facilities rely on large ventilation systems to provide safe filtered air through adequate air exchanges.
- Routine maintenance of these systems may require temporary shutdown, resulting in cessation of airflow.
- Redundant air-handling systems may not be present or feasible in older facilities.
- Close collaboration between the Heating Ventilation Air Conditioning (HVAC) team and Infection Prevention at VA Pittsburgh has allowed for evaluation of the potential clinical impact of routine air-handler maintenance.
- Immunosuppressed patients are more susceptible to mold infections; these patients are disproportionately found in hospitals.
- The Guidelines for Environmental Infection Control in Health –Care Facilities from the CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC) recommend relocation of immunocompromised patients when HVAC systems are shutdown.

## Hypothesis:

Viable particle counts of potentially pathogenic organisms rapidly increase when air-handlers in patient care areas are shutdown.

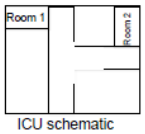
## Methods

VA Pittsburgh acute care hospital, located in Pittsburgh, PA, opened in 1954. Multiple air-handling units supply the hospital. Two shutdown events were sampled. In December 2015, the air-handler supplying a 14-bed medical intensive care unit (ICU) was shutdown for nearly a week for maintenance. At the start of shut down, 2 patient rooms were sampled. In a separate event, January 2016, the air-handler serving an ambulatory surgical care unit was shutdown for a day. No patients were present during these shutdowns.

A single stage viable particle sampler (EMLab P&K) was used, run for 10 minutes at 30 liters per minute (lpm) for shutdown sampling points, and 2.5 minutes at 30 lpm for outdoor air samples. A baseline air sample was obtained prior to shut down, at 30 minutes after shutdown and every hour thereafter. For ICU rooms, the sampler was placed on a bedside table over the patient bed, for the ASU it was placed on a table in the center of the bay. Room doors were kept closed throughout shutdown and during sampling. Outside samples were collected on the same day as shutdown samples.

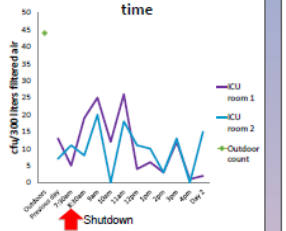
## Results

**ICU shutdown**

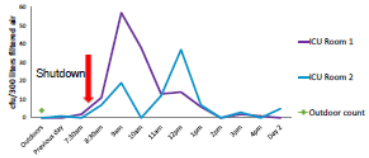



ICU schematic

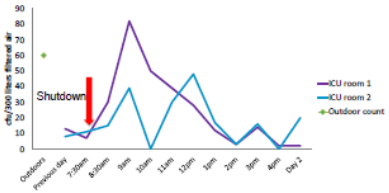
Viable bacterial count per time




Viable mold count per time



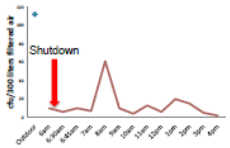

Total viable count per time



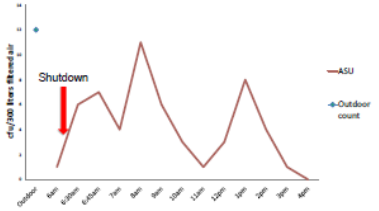

## Results

**ASU shutdown**

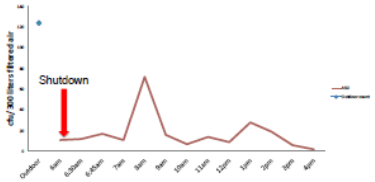
Viable bacterial count per time




Viable mold count per time




Total viable count per time




## Results

For the two ICU rooms and the surgical bay room, the average time to peak viable particle count was 1 hour, 4 hours and 2 hours respectively. This time was also the peak mold count for each room. The peak bacterial count for each room occurred at 3 hours, 1 hour and 2 hours. The time to meeting the outdoor mold count was 30 minutes and 1 hour for the ICU rooms. The ASU room did not meet the outdoor mold count, but it was raining that day. Notably, all room viable particle counts settled to baseline viable particle levels after 6 hours, 6 hours and 9 hours of no airflow respectively. Visual inspections of air ducts and air handlers revealed little dust or debris in the ducts themselves.

## Conclusions

- Viable particle count rose rapidly after shutdown, but returned to baseline after several hours.
- Routine air-handler maintenance may represent an underappreciated risk to vulnerable hospitalized patients.
- System startups should also be coordinated with Infection Prevention to protect patients from bursts of fungal spores.

## Further inquiry needs/current practice

Study data were limited, future sampling events are planned.

Air-handler shutdown impact may be due to dust and debris in the clinical area rather than inside the handler; dust adhering to ceilings and high surfaces may fall with changes in pressure.

Return to baseline prior to start-up likely due to decreased activity in area in empty unit.

Decisions regarding patient safety included: requiring patients be moved from critical areas during air handler shutdowns lasting longer than one hour, and patients being returned after 1 hour of start-up to allow for air-cleansing.

## Limitations

- Logistics of air-sampling limited sample size
- Sampling occurred when air-handler shutdowns were required for maintenance
- The two areas sampled are served by different air-handling systems and duct work
- Differences in room use and cleaning likely affect findings
- So far we have not captured air-handler start-up

## Acknowledgments

We thank the VAPHS Infection Prevention for tireless dedication to patient safety and our administration for continued support in providing the highest quality care to our Nation's Veterans.

The data presented here was gathered as part of non-research activities for quality improvement. As such, Memorandum LD-077 has been completed. This information has been approved for presentation.

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PL Harris et al. Poster at SHEA Spring Meeting, 2016

# Take home messages:

- Ambient air contamination with pathogenic organisms occurs but differs based on the organism
- Ambient air contamination might be associated:

-HVAC functionality

-Patient status

-Room occupancy

-Geographical location of hospital/season (outside temperature/humidity)

-Unit temperature/humidity

-Economic viability of the hospital (?)