Is the Inanimate Environment a Significant Contributor to the Spread of CRE in Healthcare Settings?

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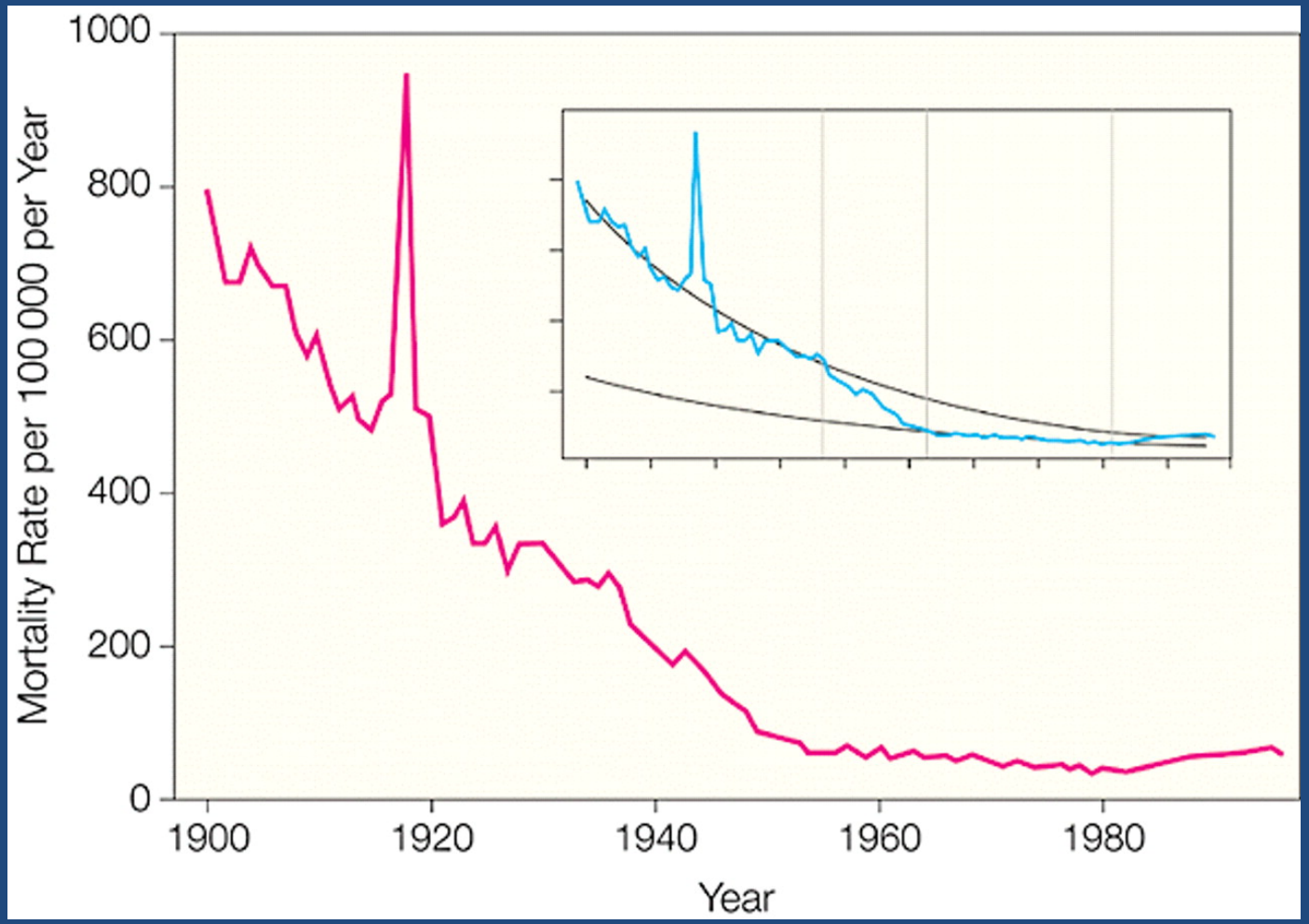
Two Part Talk

- CRE and the inanimate hospital environment
- KPC control in Chicago

Hygeia

Ancient Greek goddess of prevention, nutrition, sanitation

Crude Infectious Disease Mortality Rate in the United States from 1900 Through 1996



Armstrong, G. L. et al. JAMA 1999;281:61-66.

What is the role of contamination of inanimate surfaces in the transmission of nosocomial pathogens?

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- In the U.S. prior to 1970, surveillance cultures of the hospital environment (surfaces, air) were routine.

What is the role of contamination of inanimate surfaces in the transmission of nosocomial pathogens?

- In 1970, CDC and AHA recommended discontinuing routine environmental cultures.
  - Methods were labor-intensive, lacked sensitivity
  - No meaningful standards for permissible contamination
  - Contamination of surfaces common, but could not be linked reliably to infection

What is the role of contamination of inanimate surfaces in the transmission of nosocomial pathogens?

- More recently, this view has been reconsidered
- Newer studies suggest a role for an environmental reservoir in transmission of some pathogens
  - *Clostridium difficile*, MRSA, VRE, MDR *Acinetobacter baumannii,* norovirus

What changed?

- Higher quality study designs
- Outcomes included colonization as well as infection
- Focus on high touch surfaces
- Given difficulty in achieving control of cross-transmission with other infection control interventions, e.g. hand hygiene, adjunctive approaches were reassessed

Transmission of Pathogens in Hospitals

Patient A → HCW Hands → Patient B

Transmission of Pathogens in Hospitals

Transmission of Pathogens in Hospitals

Criteria for evaluating the strength of evidence for environmental source of colonization or infection

1. The organism can survive after inoculation onto surface and/or can be cultured from the environment in patient care areas.
   a. Molecular strain typing demonstrates that organisms identified in clinical and environmental cultures are the same.

Modified from: Guidelines for Environmental Infection Control in Healthcare Facilities. http://www.cdc.gov/ncidod/dhqp/gl_environfection.html, 2003.

Criteria for evaluating the strength of evidence for environmental source of colonization or infection

2. The organism can be cultured from hands or gloves of HCWs who touch the environmental surfaces.
3. After hand/glove contamination, the organism can be transferred by HCW hands to a clean site on a patient or in the environment.

Modified from: Guidelines for Environmental Infection Control in Healthcare Facilities. http://www.cdc.gov/ncidod/dhqp/gl_environinfection.html, 2003.

Criteria for evaluating the strength of evidence for environmental source of colonization or infection

4. Exposure to contamination is associated with acquisition of colonization or infection.
5. Decontamination of surfaces results in lower rates of colonization or infection.

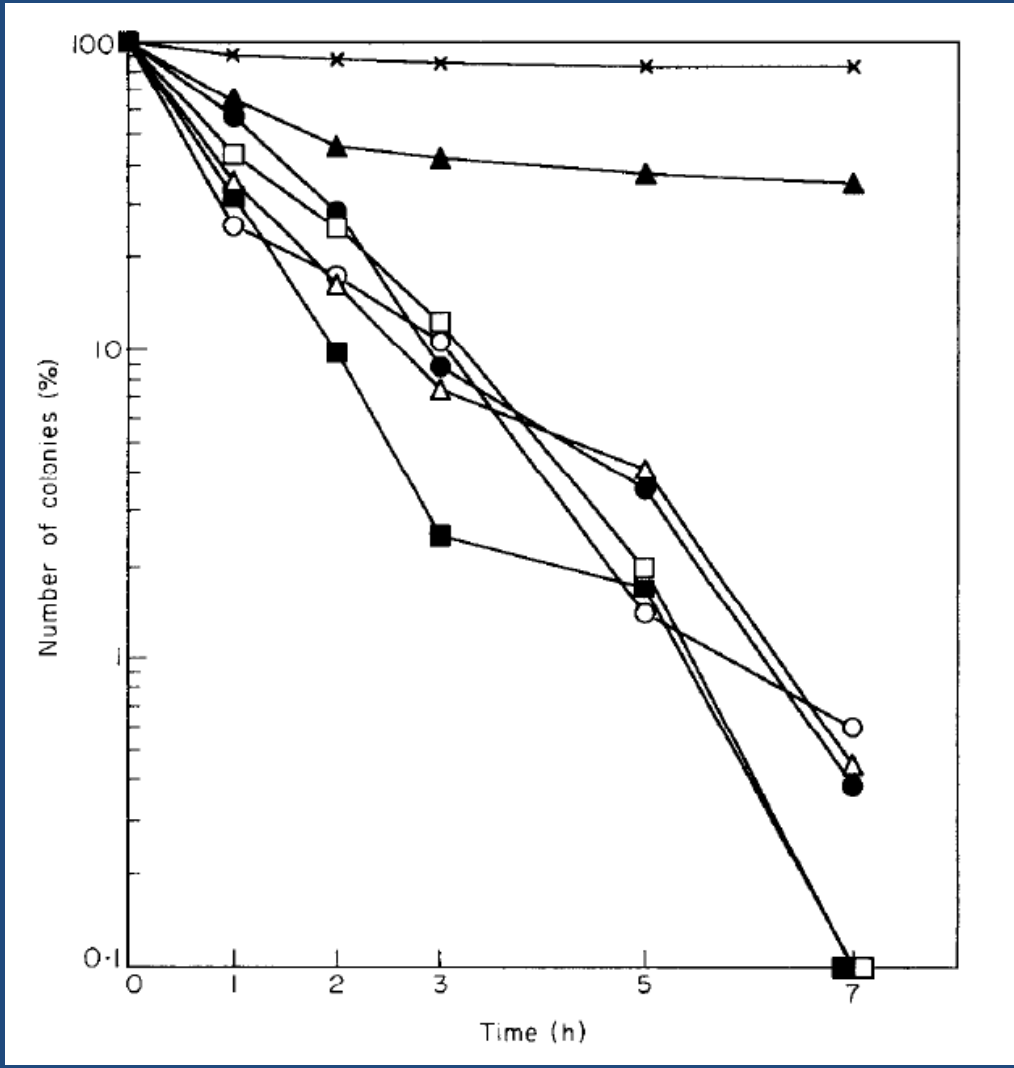
Modified from: Guidelines for Environmental Infection Control in Healthcare Facilities. http://www.cdc.gov/ncidod/dhqp/gl_environinfection.html, 2003.

Survival of Microbes in the Environment

Microorganism	Survival Time
Clostridium difficile (spores)	>5 months
Enterococcus spp., including VRE	5 days to >46 months
Staphylococcus aureus, including MRSA	7 days to >12 months
Acinetobacter spp.	3 days – 11 months
Pseudomonas aeruginosa	6 hours to 16 months
Klebsiella spp.	2 hours to >30 months
E. coli	1.5 hrs – 16 months
Norovirus	8 hours to >2 weeks

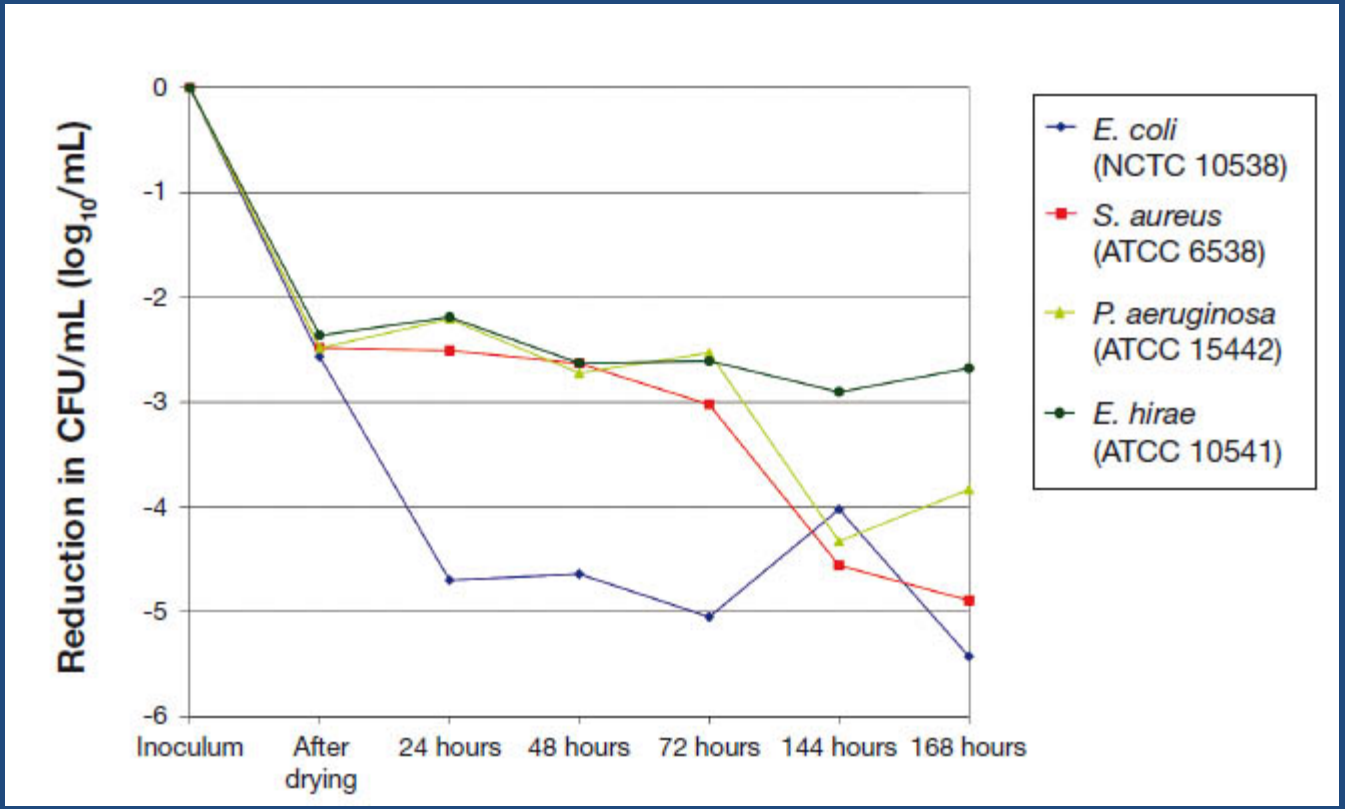
Adapted from: Kramer A et al. BMC ID 2006, 6:130.

Survival of Bacteria Under Dry Conditions



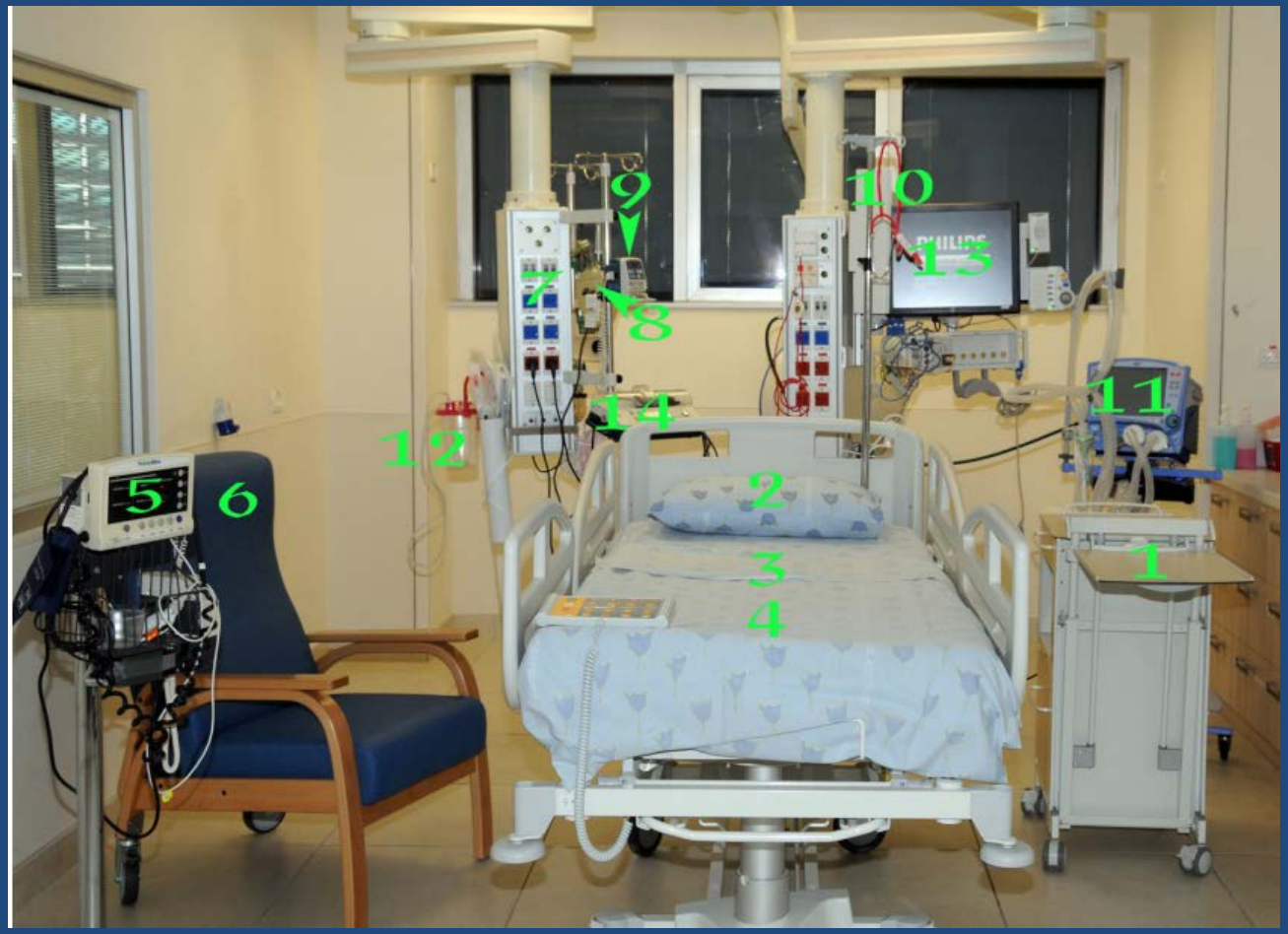
Hirai Y. JHI 1991, 19:191.

Survival of Bacteria Under Dry Conditions



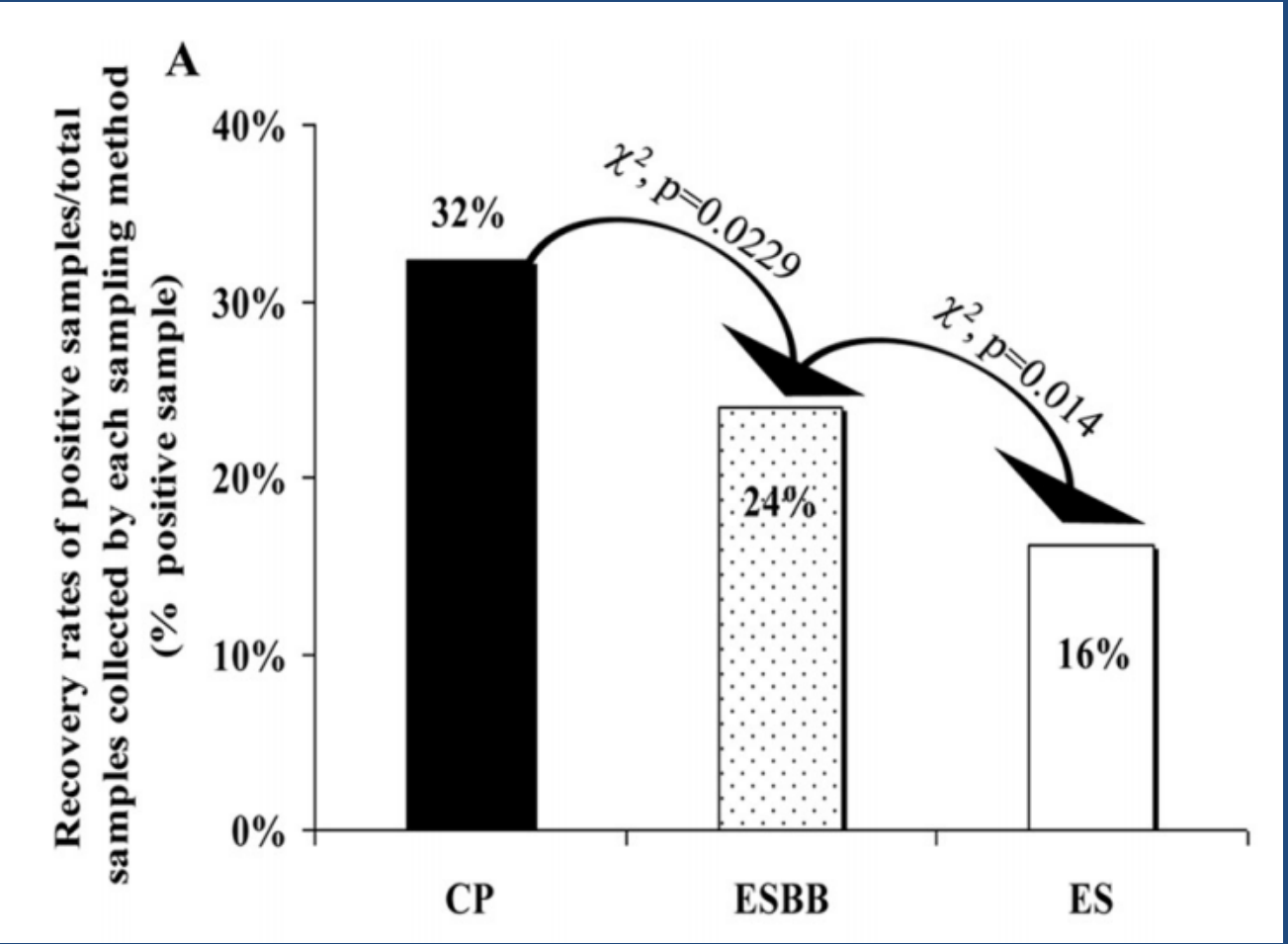
Huber NO. AJN 2011, 111:30.

KPC Contamination of Healthcare Environment



Lerner A et al. JCM 2013, 51:177

KPC Contamination of Healthcare Environment



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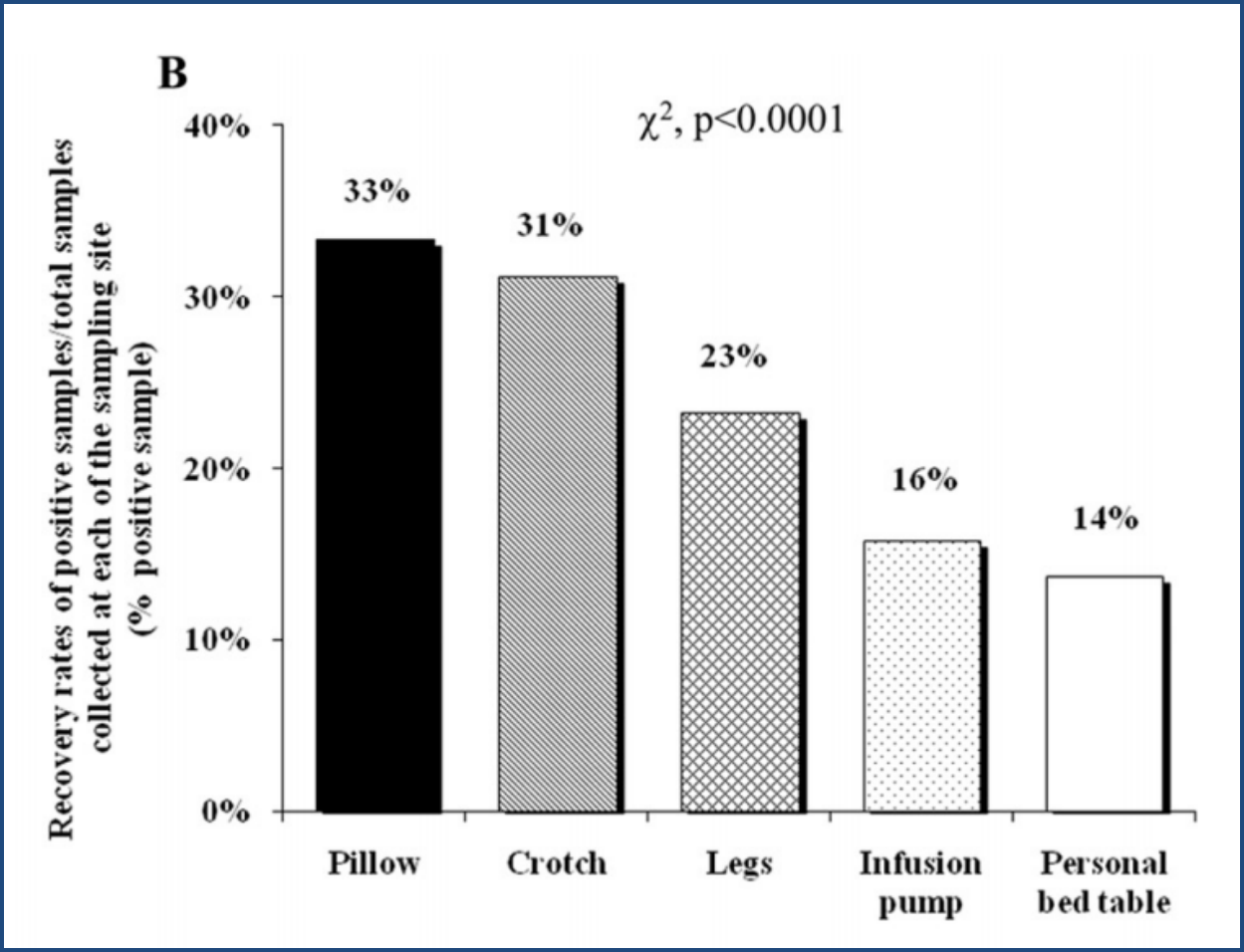
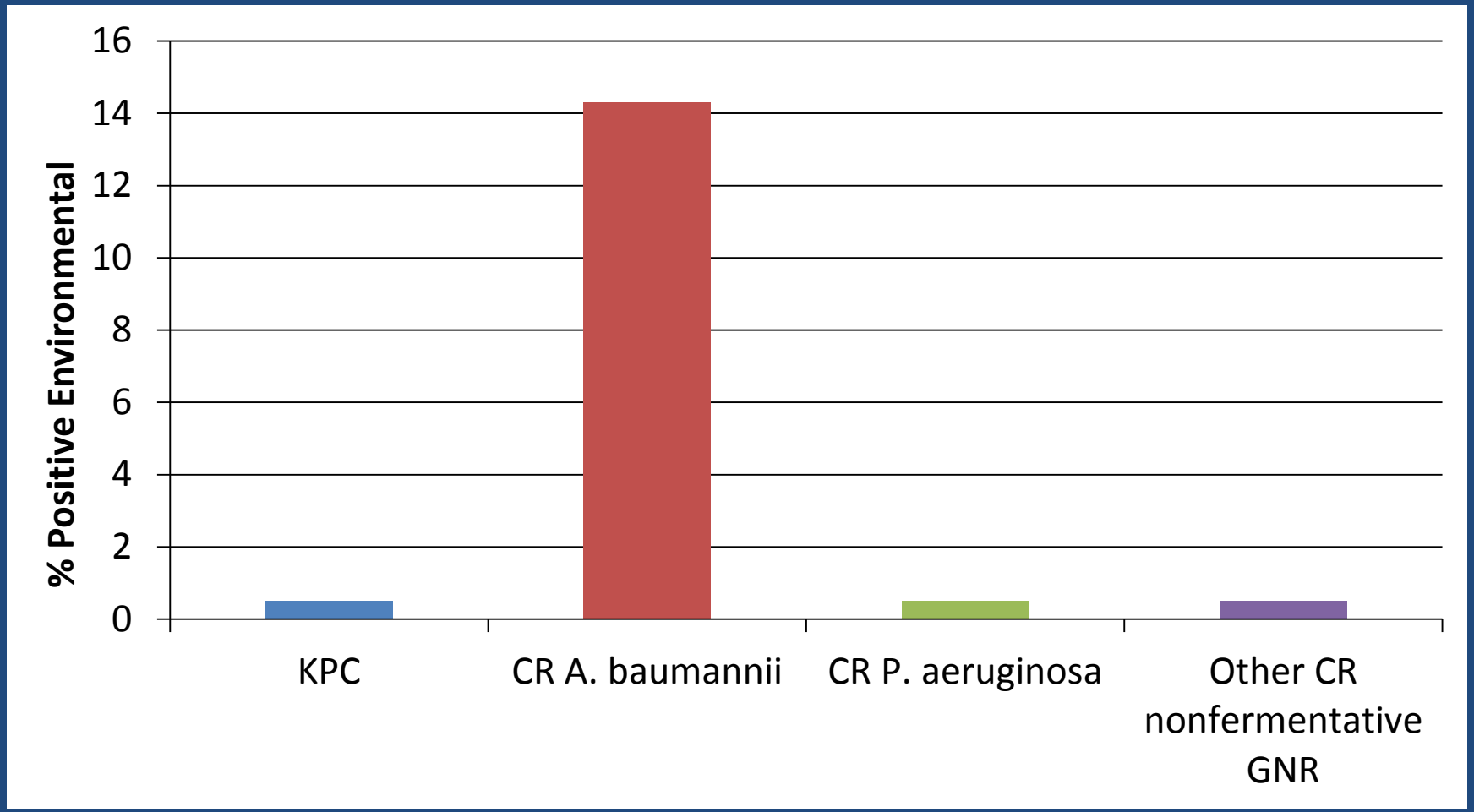


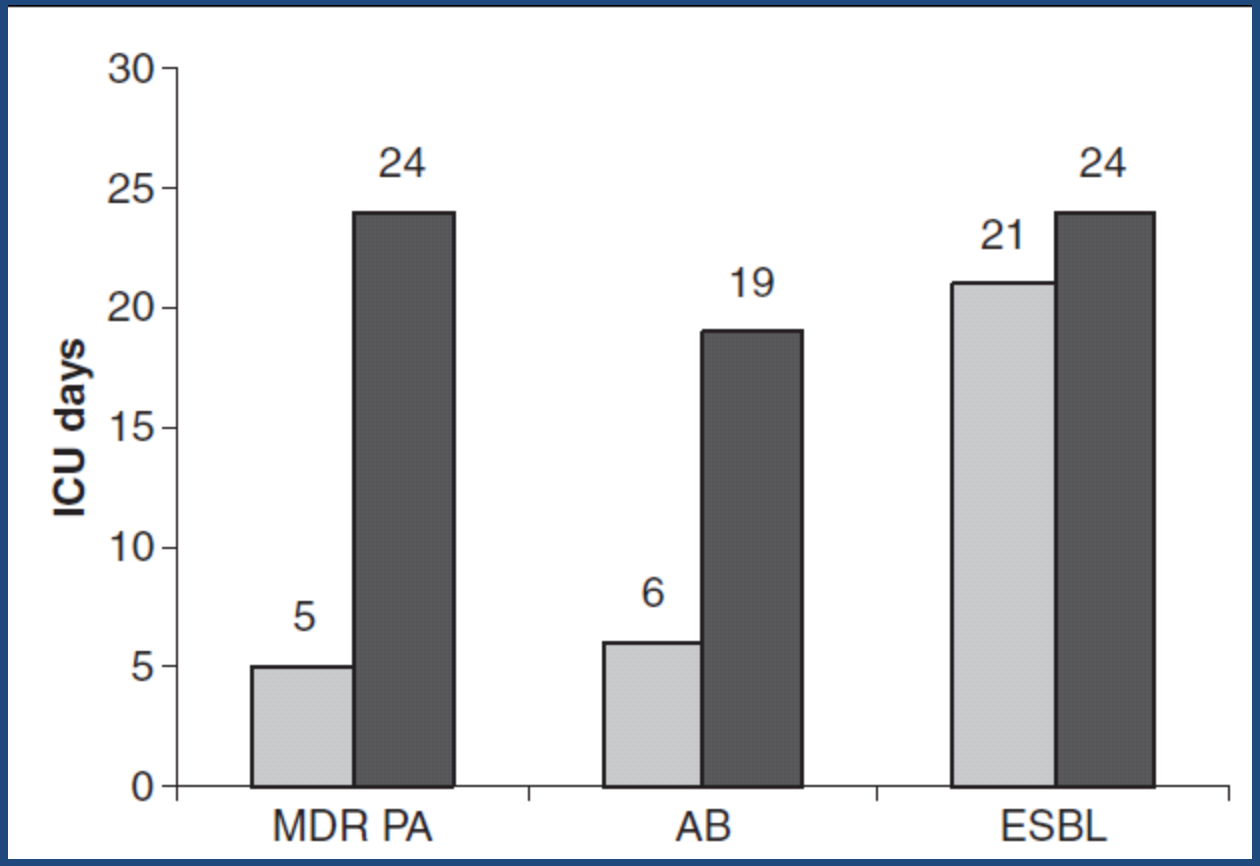
Lerner A et al. JCM 2013, 51:177

Environmental Contamination with Carbapenem-Resistant GNR in LTACHs



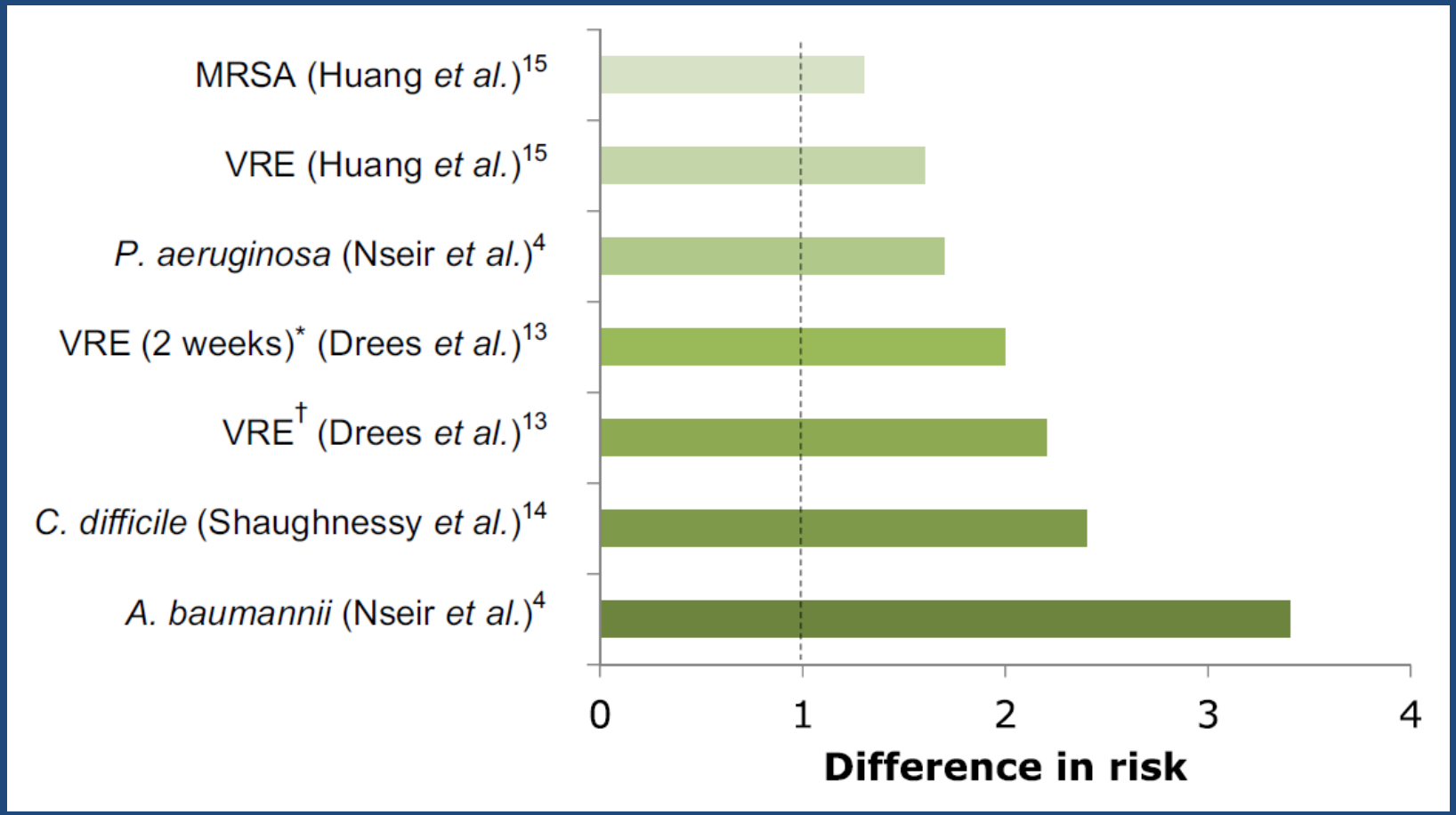
Thurlow CJ et al. ICHE 2013, 34:56.

No increased risk of ESBL acquisition for patients housed in room of former ESBL patient



Nseir S et al CMI 2011, 17:1201.

Increased risk of acquisition of MDROs for patients housed in rooms occupied by MDRO+ patients



Otter JA et al. AJIC 2013, 41:S6.

Is environmental contamination with CRE more important during outbreaks?

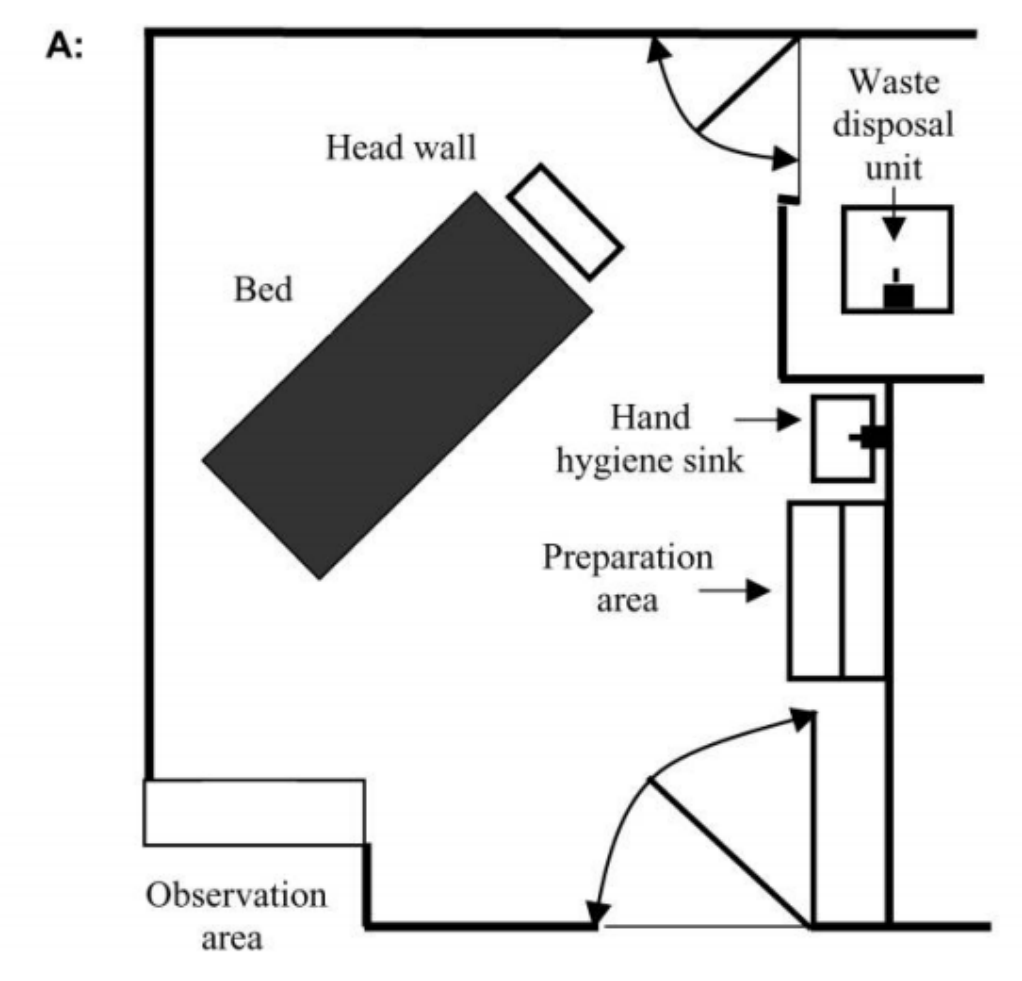
"In reflection, we believe that meticulously implementing infection control precautions that have been recommended by CDC [6], such as hand hygiene, cohorting, and active surveillance, most likely contributed the most, and remediation of environmental contamination the least, to our success, based on the paucity of positive environmental cultures and the lack of epidemiological data suggesting environmental spread."

Palmore TN and Henderson DK. CID September 5, 2013, ePub ahead of print.
Snitkin ES et al. Sci Transl Med 2012 Aug 22, 4(148):148ra116.

Sink drains as reservoirs for CRE and other MDR GNR

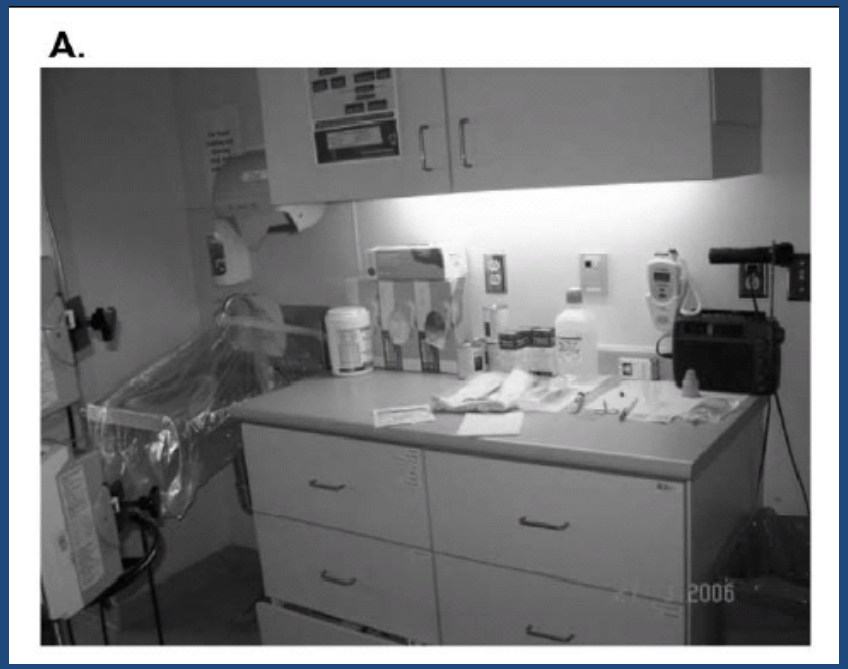
- Incorrect usage (disposal of patient waste) in handwashing sinks can contaminate drains
- Biofilm formation
- Splash back risk if other sink and room design flaws present
  - Shallow sink bowl
  - Direct flow of water from tap into drain
  - Proximity of sink to patient and clean prep areas

MDR *P. aeruginosa* ICU Outbreak



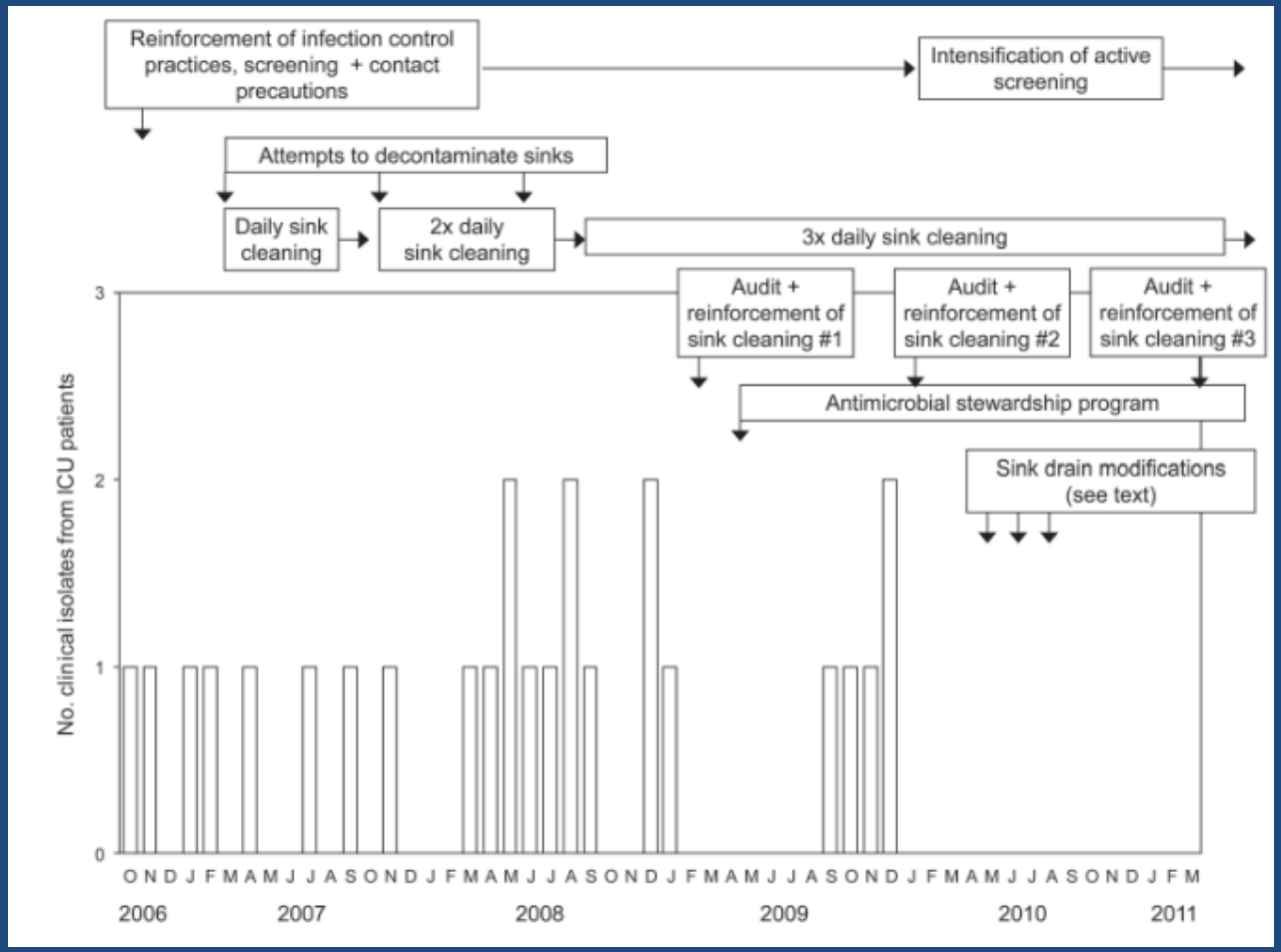
Hota S et al ICHE 2009, 30:25.

MDR *P. aeruginosa* ICU Outbreak



Hota S et al ICHE 2009, 30:25.

Outbreak of β-lactamase-producing *K. oxytoca* associated with contaminated ICU handwashing sinks



Lowe C et al. EID 2012, 18:1242.

Are contaminated sink drains an important reservoir for CRE?

- 30-month, multispecies outbreak of *bla*$_{IMP}$+ CRE in Australian ICU
- 10 infections
  - 5 *K pneumoniae*
  - 4 *S marcescens*
  - 1 *E cloacae*
- *bla*$_{IMP}$+ *S marcescens* isolated repeatedly from sink drain
  - Matched clinical isolates by PFGE

Kotsanas D et al MJA 2013, 198:267.

Summary

- Evidence for an epidemiologically significant environmental reservoir for CRE in healthcare settings weaker than for other MDROs
- CRE can be found in inanimate healthcare environment but survival time is probably lower than for some other MDROs, e.g. MDR *A. baumannii*
- No demonstrated increased risk of acquisition of ESBL+ Enterobacteriaceae for patients housed in rooms occupied by ESBL+ patients

Summary

- During outbreaks, sink drains might be considered as possible sources of CRE if additional room design problems identified

Epidemiology and Control of KPC-Producing *Enterobacteriaceae* in Chicago

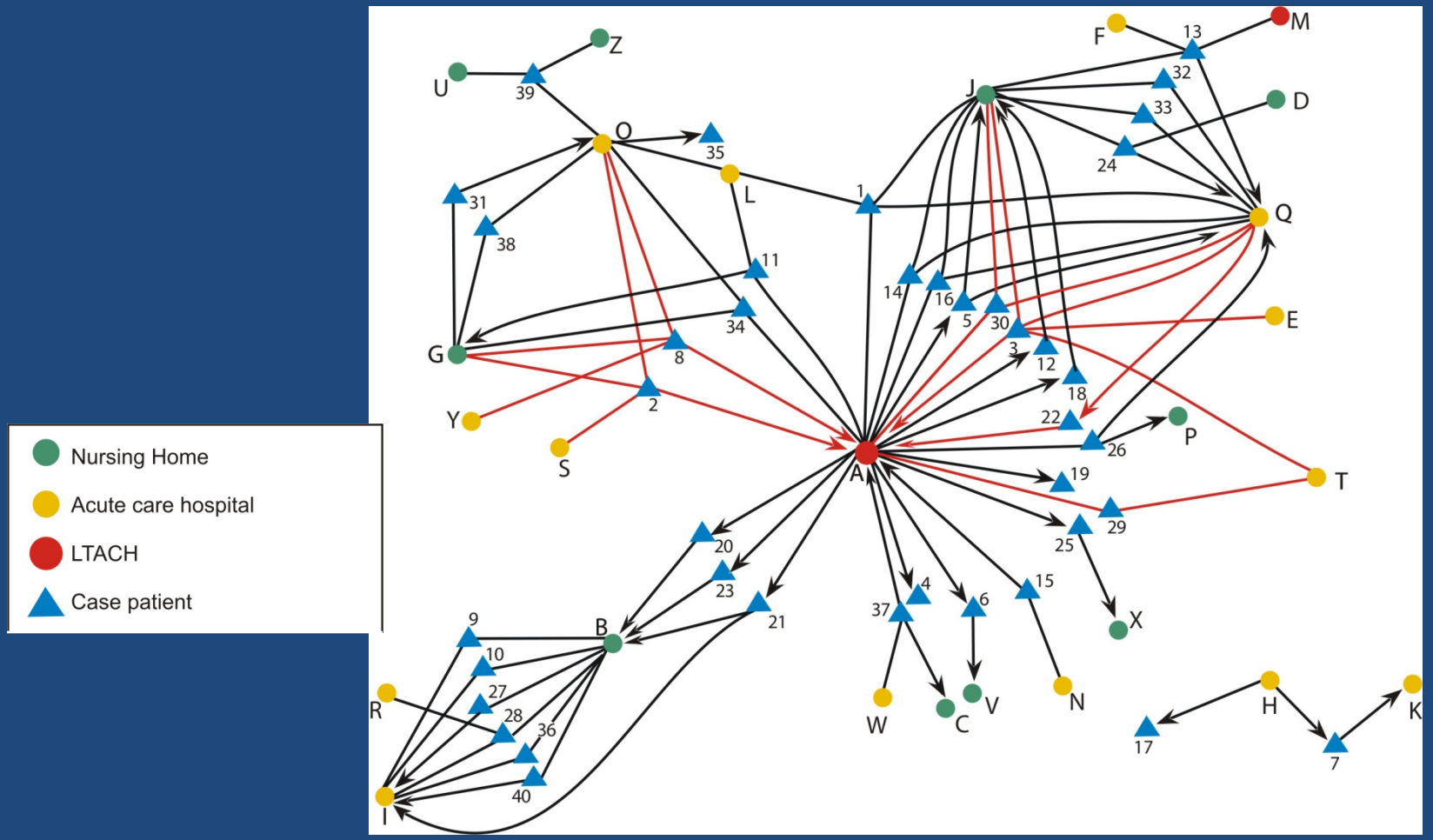
KPC in Chicago

- KPC first recognized in Chicago area in December 2007
- Patient transferred to a hospital in suburban Cook County from a skilled nursing facility in Northwest Indiana

KPC in Chicago

- May 2008 first KPC+ case identified at Rush
- Transferred from acute care hospital in NW Indiana

Emergence and Rapid Regional Spread of KPC



Won SY et al. CID 2011; 53:532.

REALM Project

- A voluntary MDRO surveillance network of hospitals in the city of Chicago
- Serial point prevalence surveys every 6 months
- KPC surveillance began late 2010

Lin MY et al. Clin Infect Dis 2013, 57:1246.

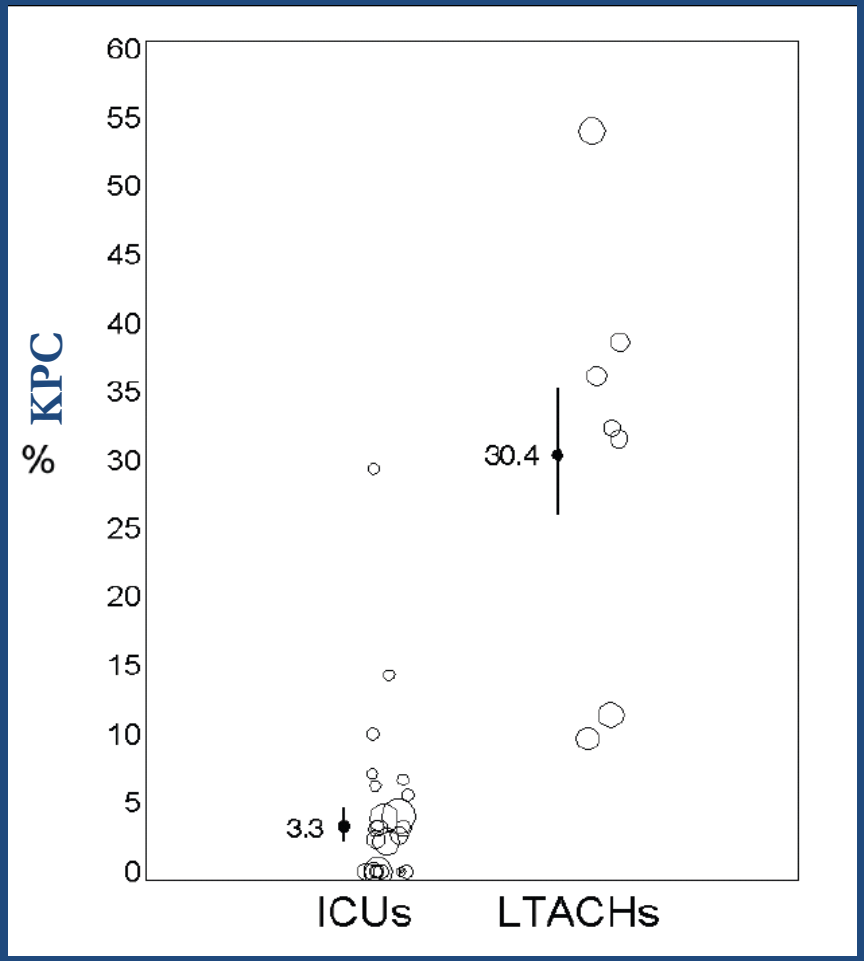
KPC Prevalence in Chicago Healthcare Facilities

- 24 of 25 eligible hospitals and 7 of 7 eligible LTACHs participated in the first 2 KPC surveys

- Number of patients cultured:
  - 909 ICU patients
  - 391 LTACH patients

Lin MY et al. Clin Infect Dis 2013, 57:1246.

KPC Prevalence in Chicago Healthcare Facilities



- KPC prevalence 9-fold higher in LTACHs than in short-stay acute care hospital ICUs

Lin MY et al. Clin Infect Dis 2013, 57:1246.

Is long term care residence a risk factor for KPC colonization on admission to acute care hospitals in Chicago?

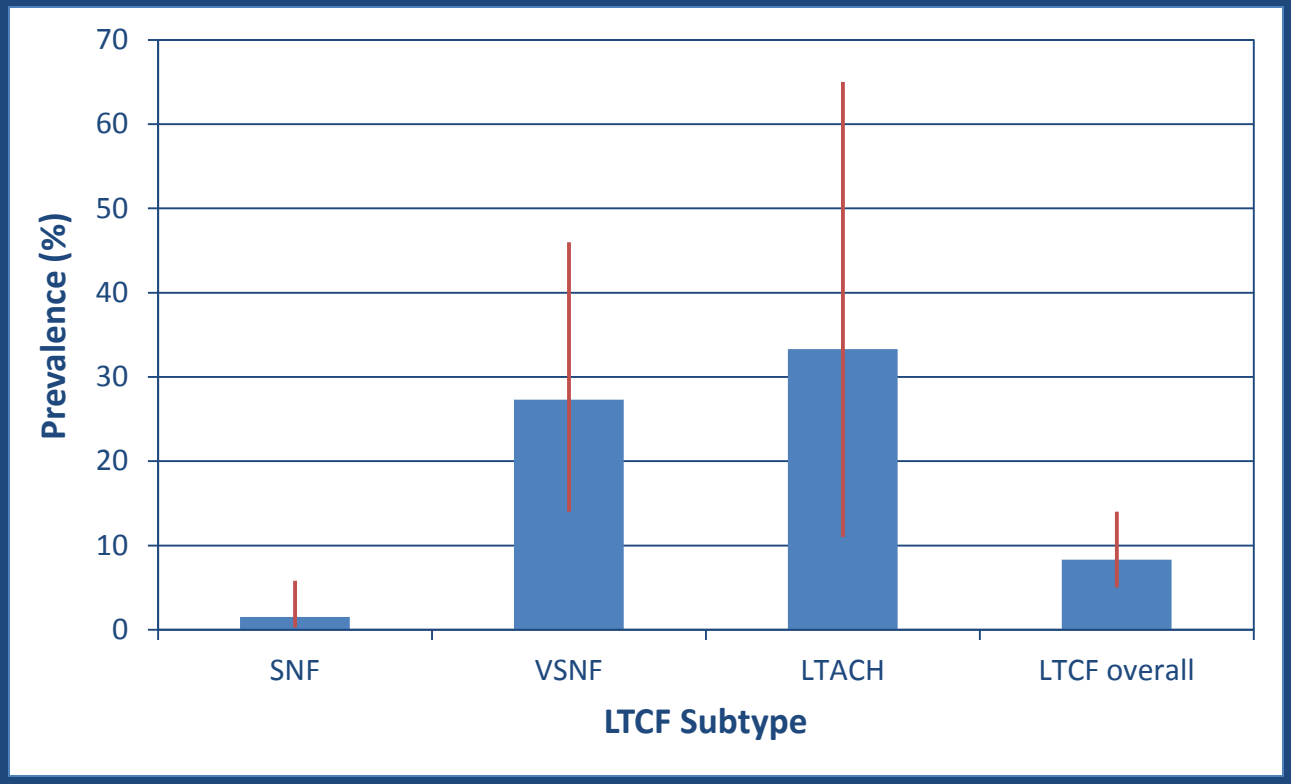
	LTCF Patients (N=180)	Community Patients (N=180)
Prevalence of KPC	15 (8.3%)	0 (0%)

P <0.001

- 15 patients admitted from 7 different LTCFs

Prabaker K et al. Infect Control Hosp Epidemiol 2012, 33:1193.

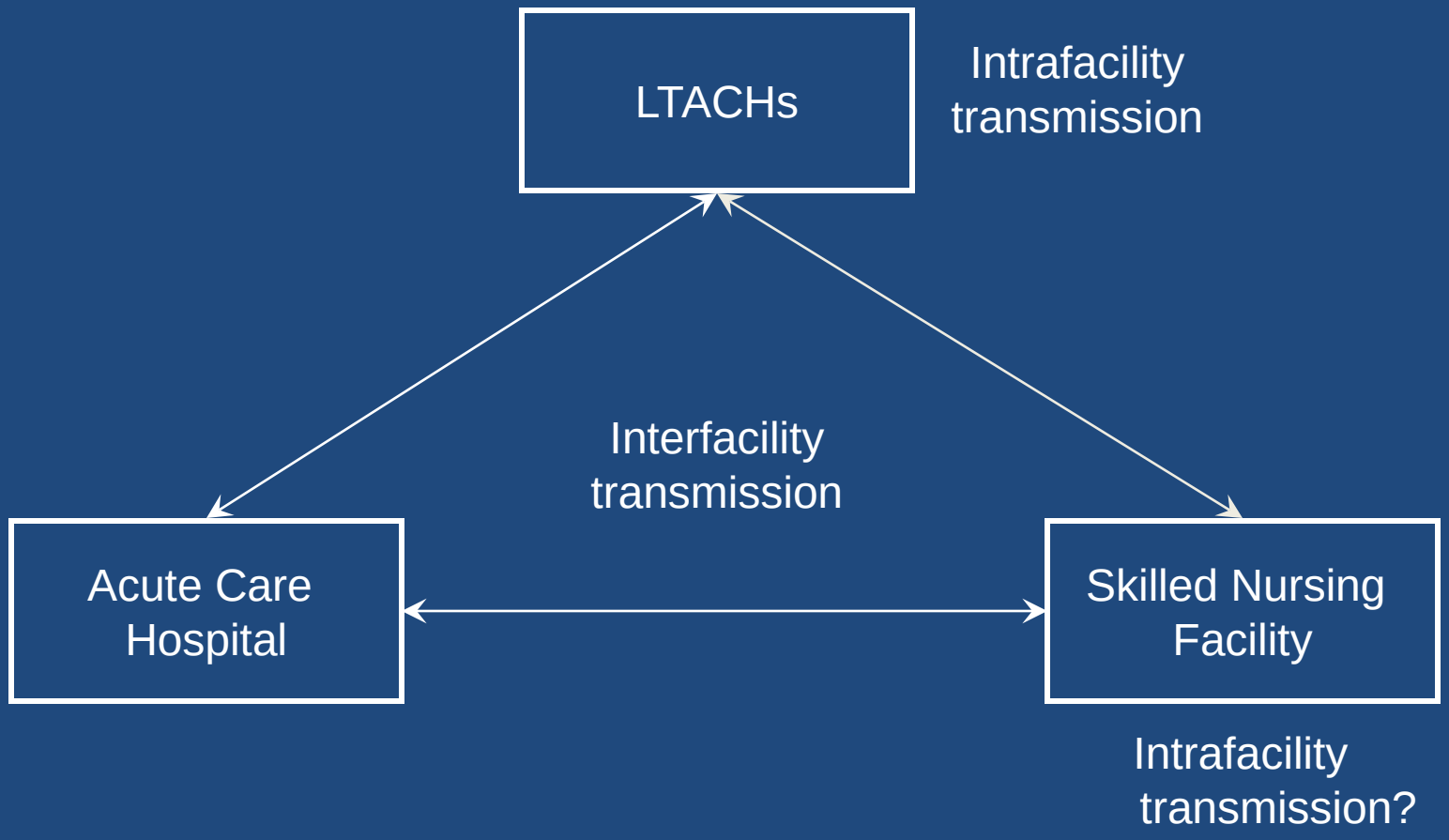
KPC Prevalence Differed among Patients Admitted from Different Types of LTCFs



P <0.001

Prabaker K et al, Infect Control Hosp Epidemiol 2012, 33:889.

Epidemiology of Regional KPC Spread



Regional KPC Control Plan

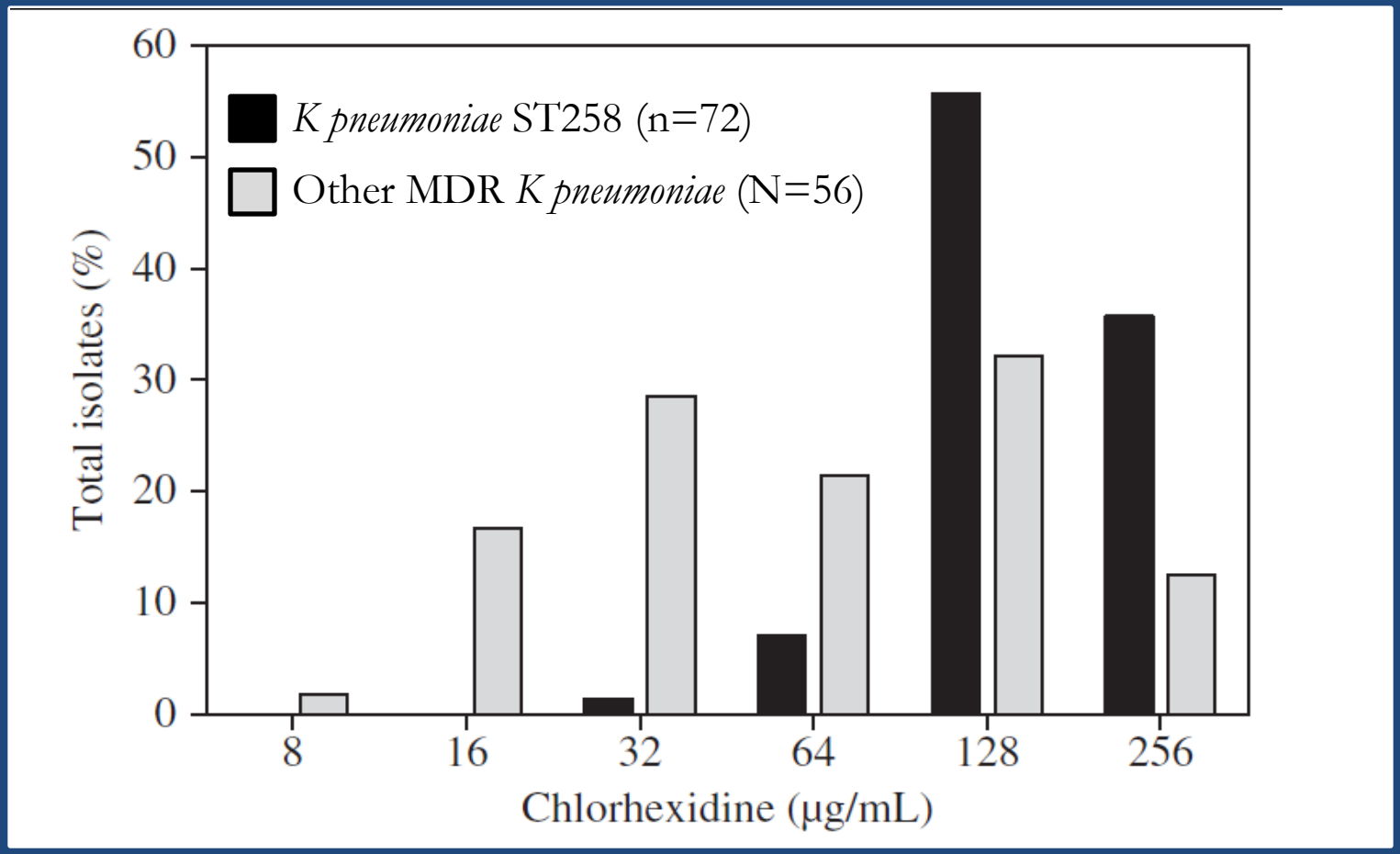
- Decrease cross-transmission of KPC in high-prevalence healthcare facilities
  - Infection prevention bundle
- Improve communication of KPC status among transferring healthcare facilities

KPC Common on Skin but Rare in Environment of LTACH Patients

- 23/24 (96%) patients ≥1 skin site KPC-positive
  - 49/96 (51%) skin cultures KPC-positive
- 2/371 (0.5%) environmental sites in patient rooms or common areas grew KPC

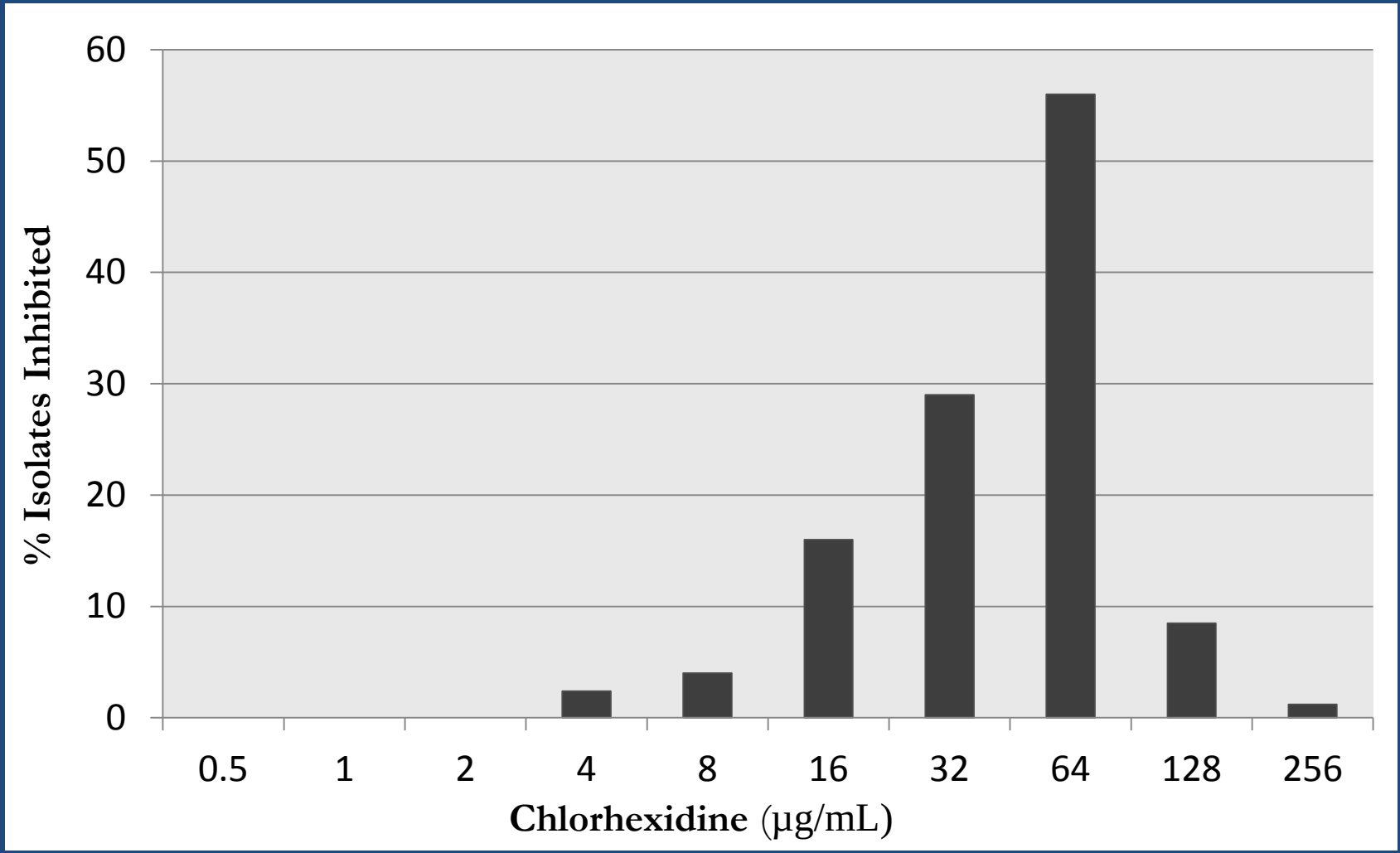
Thurlow CJ Infect Control Hosp Epidemiol 2013, 34:56.

Reduced Susceptibility of *K pneumoniae* ST258 to Chlorhexidine



Naparstek L et al JHI 2012, 81:15.

KPC-Positive *K pneumoniae* (N=82)



Thurlow CJ et al. Infect Control Hosp Epidemiol; 2013; 34:56.

Regional KPC Control Project: KPC Control in LTACHs

- KPC Control Bundle
- Active surveillance and contact isolation
  - Admission and biweekly rectal swab cultures
- Geographic separation of KPC+ patients
  - Private rooms or cohorts
- Daily bathing with 2% CHG cloths (Sage, Inc.)
- HCW education and adherence monitoring
  - Focus on hand hygiene

Study Design and Setting

- Design: Stepped wedge randomized cluster
- Setting: 4 of 7 LTACHs in metro Chicago

		Time				
		1	2	3	4	5
LTACH	A	0	X	X	X	X
	B	0	0	X	X	X
	D	0	0	0	X	X
	C	0	0	0	0	X

- Pre-intervention: 16-29 months
- Intervention: 12-19 months

Outcomes

- Primary outcome
  - KPC prevalence in LTACHs
- Secondary outcomes
  - KPC incidence
  - CRE-*Klebsiella* spp. in any clinical culture*
  - CRE-*Klebsiella* spp. in blood*
  - Any pathogen in blood*
    - Blood culture contaminants excluded

*NHSN MDRO Module, LabID event, hospital onset

Summary

- KPC spread rapidly throughout metropolitan Chicago soon after introduction
  - Establishment of high-prevalence reservoirs in LTACHs and (possibly) other high-acuity skilled nursing facilities
  - Frequent transfer of KPC-positive patients from LTACHs to other healthcare facilities
- Prevalence of KPC in acute care hospital ICUs remains low

Summary

- A bundled infection control intervention was successful in reducing KPC prevalence and incidence at 3 of 4 LTACHs
- The bundled intervention was successful in reducing KPC infections at all study facilities
- XDRO information exchange has potential to improve reporting of CRE status of patients at time of healthcare facility transfer

Team KPC

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- Lluisa Guillem
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- Monica Sikka
- Caroline Thurlow
- Bill Trick
- Shawn Vasoo
- Mike Vernon
- Shayna Weiner
- Bob Weinstein
- Sarah Won
- CDC Prevention Epicenters Program

Thank You!