Carbapenem-Resistant Enterobacteriaceae: Epidemiology and Prevention

Alice Guh, MD, MPH

Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention

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Outline

- **Describe the epidemiology of carbapenem-resistant Enterobacteriaceae (CRE) in the United States**
- **Review CRE prevention strategies**
  - Facility-level interventions
  - Regional approach to CRE prevention

Enterobacteriaceae

- **Normal human gut flora and environmental organisms**
  - *E. coli*
  - *Klebsiella* species
  - *Enterobacter* species
- **Range of human infections: UTI, wound infections, pneumonia, meningitis**
- **Important cause of healthcare- and community-associated infections**
  - Some of the most common organisms encountered in clinical laboratories

Pathogens Reported to NHSN 2009-2010

	Overall percentage (rank)	CLABSI	CAUTI	VAP	SSI
P. aeruginosa	8% (5)	4%	11%	17%	6%
Enterobacter spp.	5% (8)	5%	4%	9%	4%

These three groups of organisms make up about 25% of organisms reported to NHSN Device and Procedure module

Sievert D, et al. Infect Control Hosp Epidemiol 2013; 34: 1-14

Antimicrobial Resistance in Enterobacteriaceae

- **Resistance to β-lactams has been a concern for decades**
  - β-lactamases
  - Extended-spectrum β-lactamases
- **Carbapenems**
  - Extended-spectrum β-lactam agents
  - Four FDA-approved agents in U. S.
    - Doripenem, Ertapenem, Imipenem, Meropenem
  - Broad-spectrum agents used empirically in severe infections

Carbapenem Resistance among Enterobacteriaceae: Change in CRE Incidence, 2001-2011

	National Nosocomial infection Surveillance system, Number (%) of isolates			National Healthcare Safety Network, Number (%) of isolates		
	2001			2011		
Organism	Isolates	Tested	Non-susceptible	Isolates	Tested	Non-susceptible
Klebsiella pneumoniae* and *oxytoca	654	253 (38.7)	4 (1.6)	1,902	1,312 (70.0)	136 (10.4)
E. coli	1,424	421 (29.6)	4 (1.0)	3,626	2,348 (64.8)	24 (1.0)
Enterobacter aerogenes* and *cloacae	553	288 (52.1)	4 (1.4)	1,045	728 (69.7)	26 (3.6)
Total	2,631	962 (36.6)	12 (1.2)	6,573	4,388 (66.8)	186 (4.2)

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Mechanisms of Carbapenem-Resistance in Enterobacteriaceae

- **Extended – spectrum cephalosporinase + porin loss**
  - Extended-spectrum β-lactamases (ESBLs)
  - AmpC-type enzymes
- **Carbapenemase production**

Klebsiella Pneumoniae Carbapenemase (KPC)

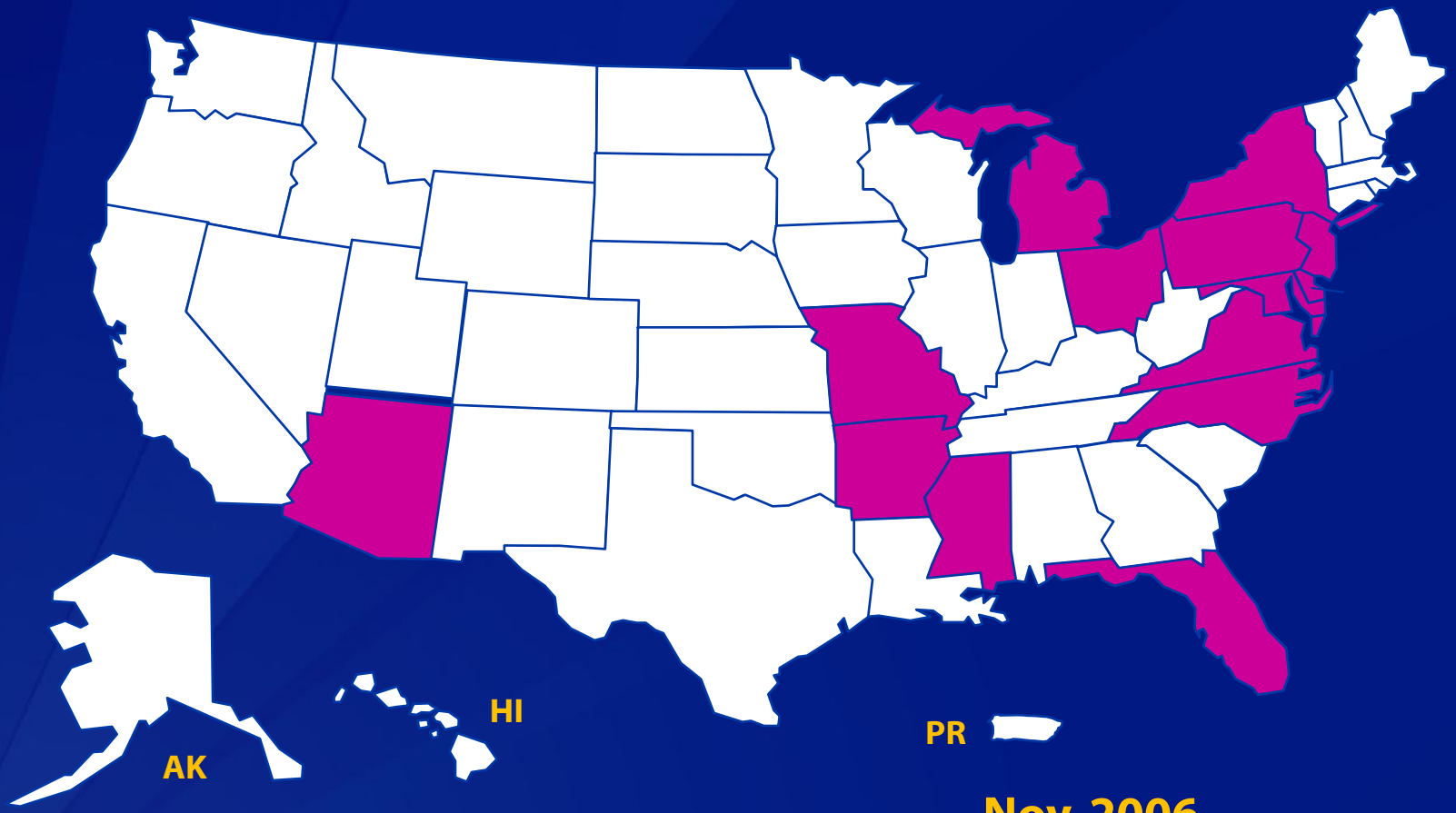
ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, Apr. 2001, p. 1151–1161 Vol. 45, No. 4
0066-4804/01/$04.00+0 DOI: 10.1128/AAC.45.4.1151–1161.2001

Novel Carbapenem-Hydrolyzing β-Lactamase, KPC-1, from a Carbapenem-Resistant Strain of *Klebsiella pneumoniae*

HESNA YIGIT,[1] ANNE MARIE QUEENAN,[2] GREGORY J. ANDERSON,[1]
ANTONIO DOMENECH-SANCHEZ,[3] JAMES W. BIDDLE,[1] CHRISTINE D. STEWARD,[1]
SEBASTIAN ALBERTI,[4] KAREN BUSH,[2] AND FRED C. TENOVER[1]*

- **First identified in North Carolina in 1996, reported in 2001**
- **Predominant carbapenemase enzyme in US**
- ***K. pneumoniae, E. coli***

KPC-producing CRE in the United States



Nov, 2006

CDC, unpublished data

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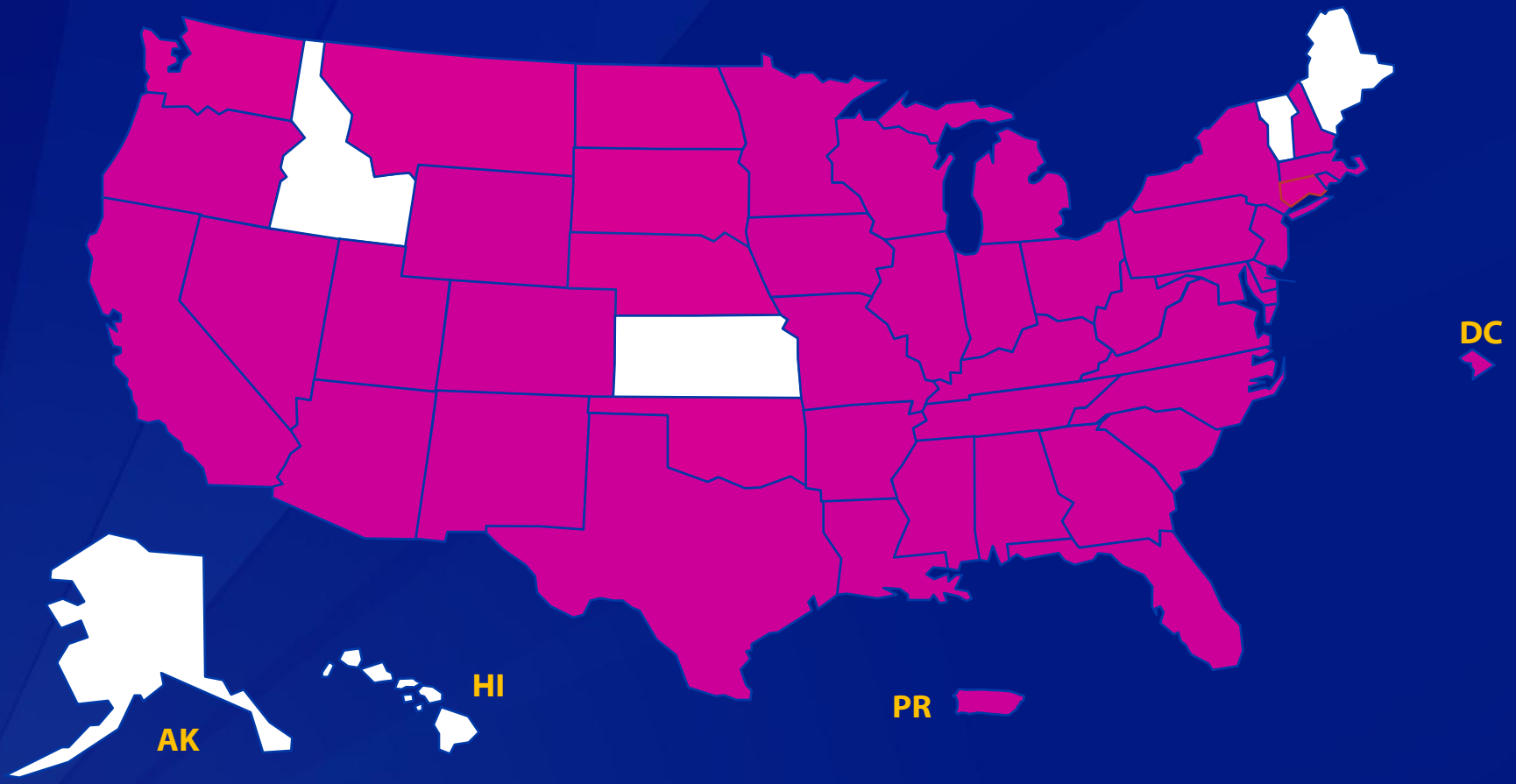
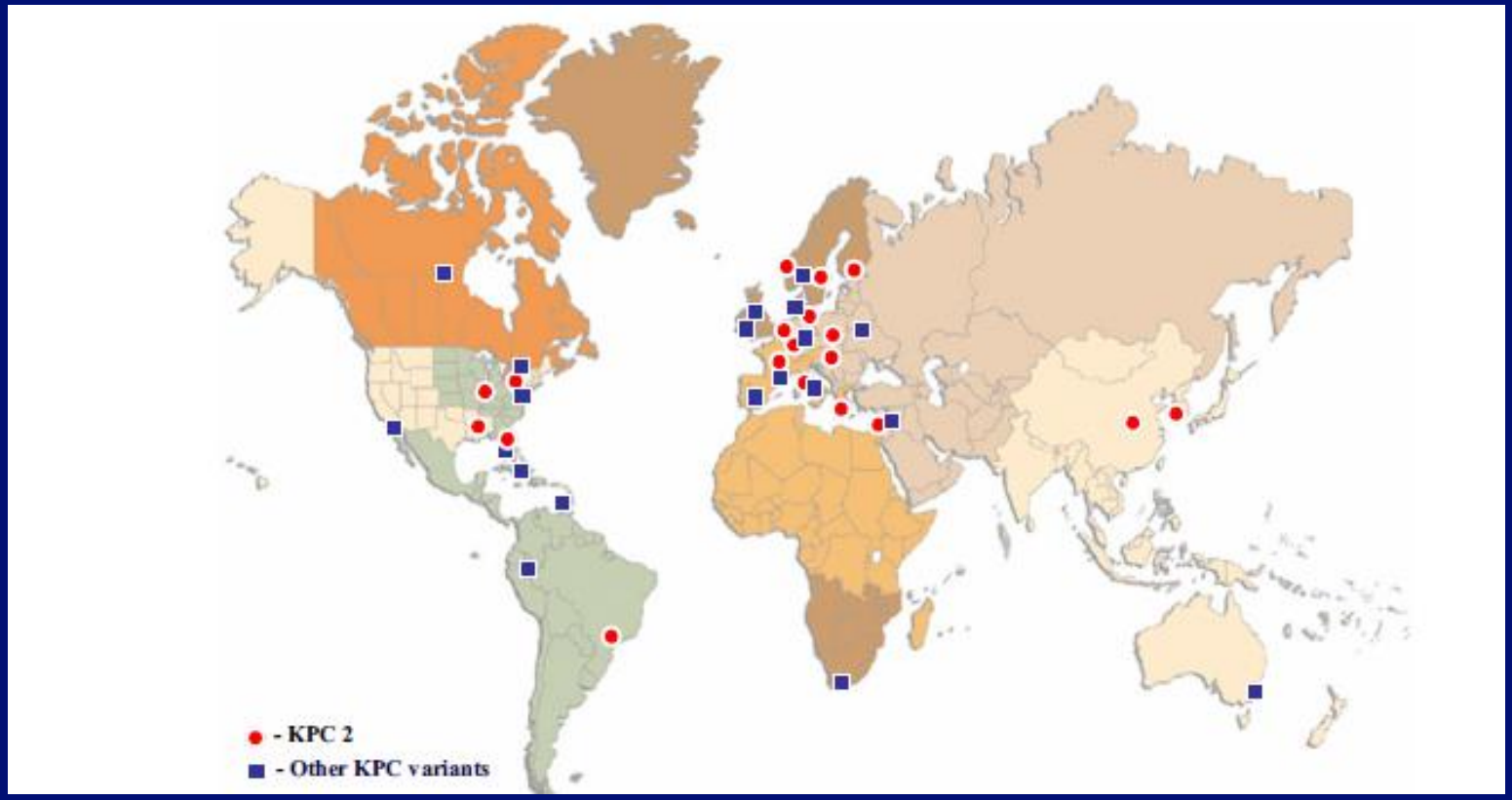


CDC, unpublished data

Worldwide Distribution of KPC



Walsh. 2010. International Journal of Antimicrobial Agents

Different Types of Carbapenemases

Enzyme	Classification	Activity	Number Identified to Date in U.S.
KPC	Class A	Hydrolyzes all β-lactam agents	
NDM-1	Class B: metallo-β-lactamase (MBL)	Hydrolyzes all β-lactam agents except aztreonam	55
IMP			4
VIM			5
OXA	Class D	Hydrolyzes carbapenems but not active against 3rd generation cephalosporins	13

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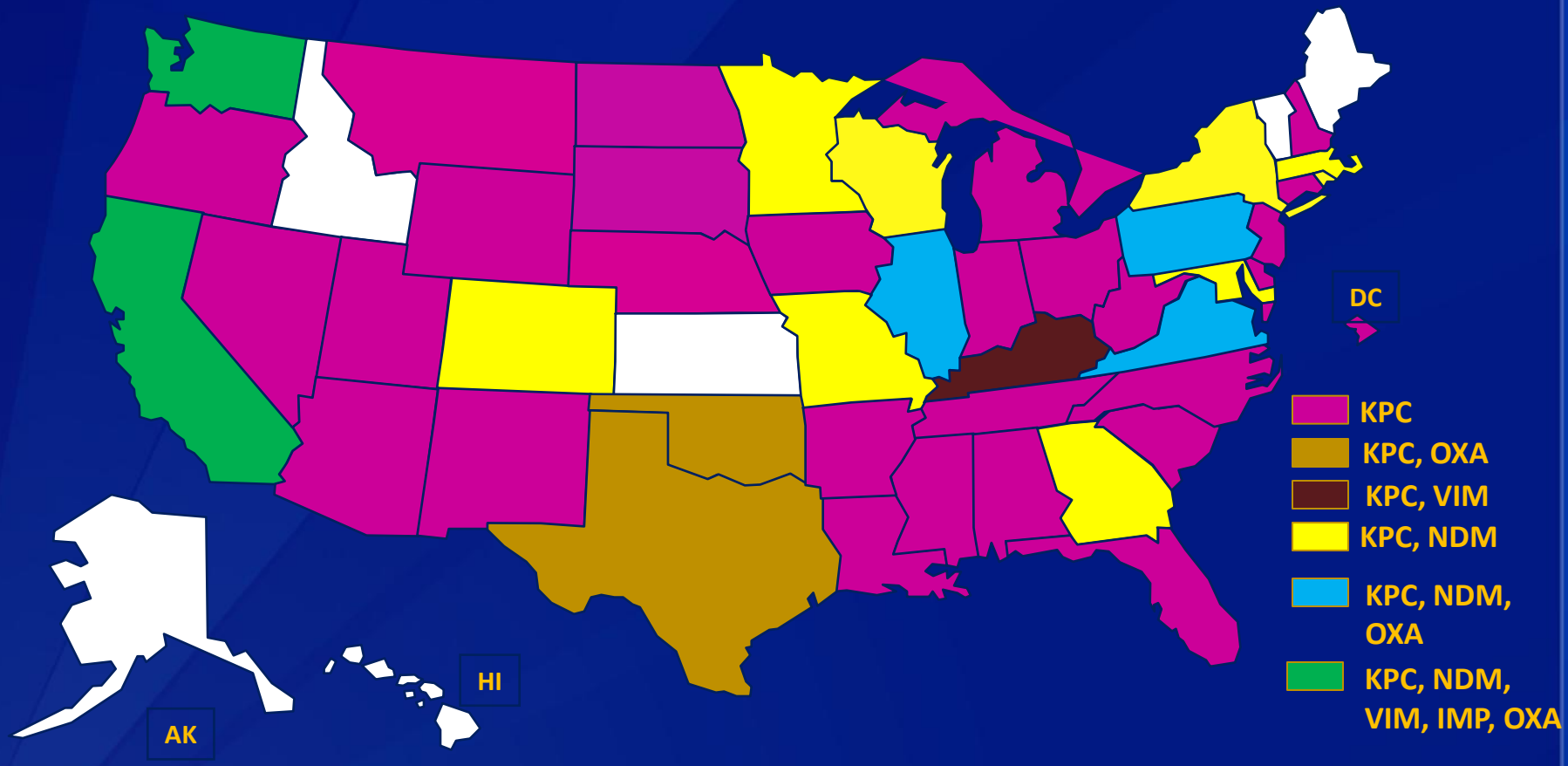
Emergence of Metallo-beta-lactamase containing Enterobacteriaceae

- **Until recently, VIM and IMP were the most common MBLs worldwide**
- **NDM-1 first described in 2009 in Swedish patient who had received medical care in India**
  - Early UK cases associated with medical care in India or Pakistan
- **NDM in the US since 2009**
  - Most are clusters of two or fewer cases
  - At least 3 outbreaks with documented transmission in 3 different states

Gupta N. Clin Infect Dis 2011;53:61-67.
Kallen et al. MMWR 2010;59(24):750.

Carbapenemase-producing CRE in the United States, August 2013



Patel, Rasheed, Kitchel. 2009. Clin Micro News
MMWR MMWR Morb Mortal Wkly Rep. 2010 Jun 25;59(24):750.
MMWR Morb Mortal Wkly Rep. 2010 Sep 24;59(37):1212.
CDC, unpublished data

Facility characteristic	Number of facilities with CRE from a CAUTI or CLABSI (2012)	Total facilities performing CAUTI or CLABSI surveillance (2012)	(%)
All acute care hospitals	181	3,918	(4.6)
Short-stay acute hospital	145	3,716	(3.9)
Long-term acute care hospital	36	202	(17.8)
Hospital bed size			
<100	48	1,609	(3.0)
100-299	46	1,480	(3.1)
300-499	41	541	(7.6)
≥500	45	258	(17.4)
Region			
Northeast	63	658	(9.4)
Midwest	30	927	(3.0)
South	50	1,503	(3.2)
West	29	804	(3.6)

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Active CRE surveillance

- **MuGSI (Multi-site Gram-Negative Surveillance Initiative) project**
  - Active, laboratory-initiated, population-based surveillance for CRE and CR *Acinetobacter* (CRAB) in 6 US sites (sterile sites and urine)
  - Pilot 8/11 to 12/11(3 sites)
    - 72 CRE (64 patients) - most (59) from one site (OR had 3)
    - Urine most common source (89%)
    - CR *K. pneumoniae* most common (68%)
    - Most with onset outside hospital (66%)
      - 41/47 (87%) had healthcare exposures (72% hospitalization)
      - 6 were community onset without healthcare exposures

Kallen et al. ID Week 2012, San Diego

Why are CRE Clinically and Epidemiologically Important?

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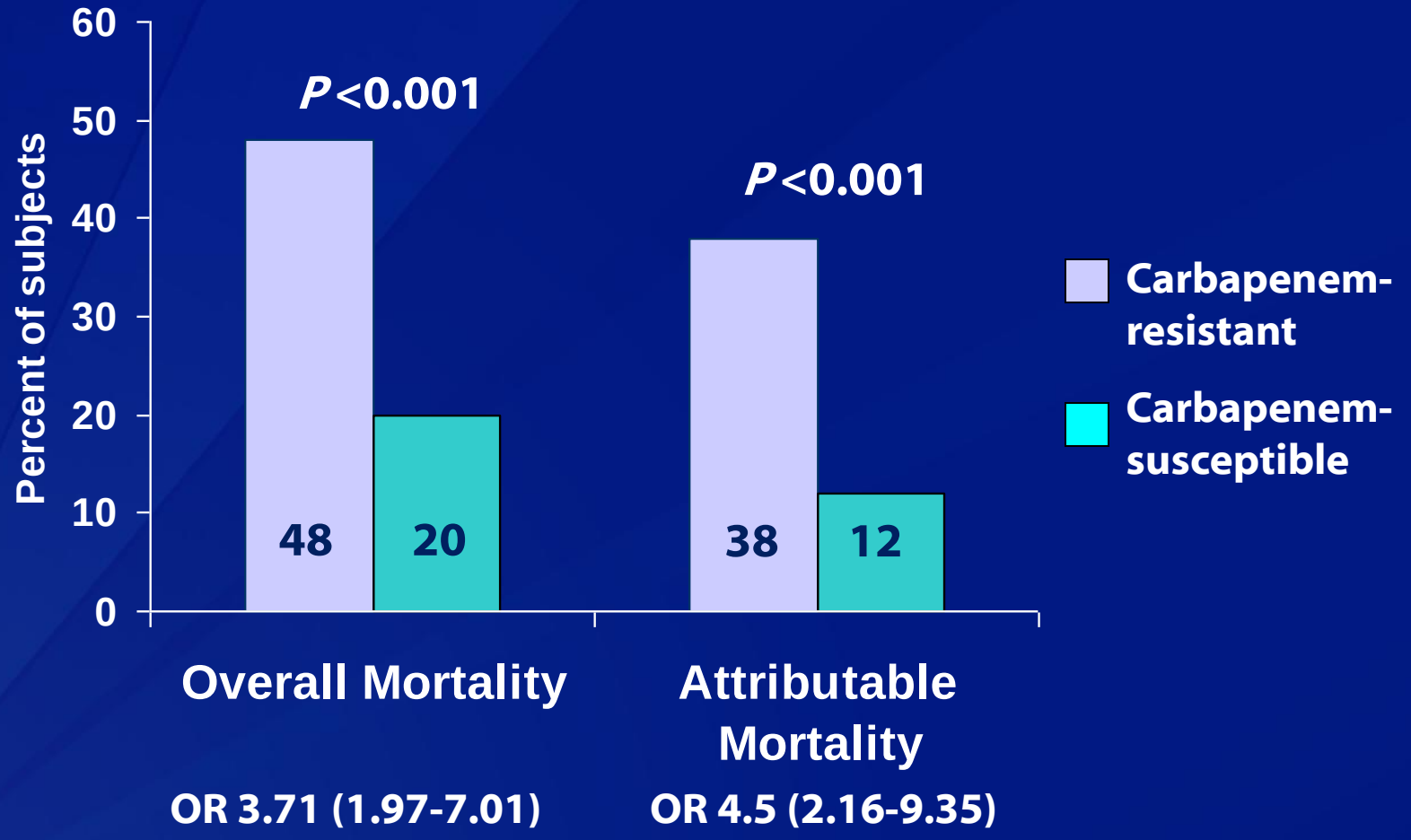
- Cause infections associated with high mortality rates

Epidemiologic Data from NYC: *K. pneumoniae* Invasive Infections



Patel G et al. *Infect Control Hosp Epidemiol* 2008;29:1099-1106.

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- **Resistance is highly transmissible**
  - Between patients
  - Between organisms – plasmids

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  - Pan-resistant strains identified
  - Could be decades before new agents are available to treat

Pan-Resistant Enterobacteriaceae

- **Report from New York City of 2 "Panresistant" *K. pneumoniae***
  - 1 patient died
  - 1 had continuing asymptomatic bacteruria

Table 1. Antimicrobial susceptibility patterns for *Klebsiella pneumoniae* isolates.

Antimicrobial	MIC value, μg/mL	
	Patient 1: urine specimen	Patient 2: blood specimen
Amikacin	≥64	≥64
Ampicillin	≥32	≥32
Aztreonam	≥64	≥64
Cefazolin	≥64	≥64
Cefepime	32	≥16
Ceftriaxone	≥64	≥64
Ciprofloxacin	≥4	≥4
Gentamicin	≥16	≥16
Piperacillin-tazobactam	≥128	≥128
Tobramycin	≥16	≥16
Trimethoprim-sulfa	≥320	≥320
Nitrofurantoin	256	NA
Ertapenem	≥8	≥8
Imipenem	≥16	≥R[a]
Moxifloxacin	NA	≥R[a]
Tigecycline	≥8	≥8
Polymyxin B[b]	4	≥16

NOTE. All susceptibility testing, except for polymyxin B, was done using the Vitek 2 automated system (bioMérieux). MIC, minimum inhibitory concentration; NA, not available.

[a] Antimicrobial agents indicated with "R" instead of an MIC value were read as susceptible by the automated system, but findings were modified on the basis of polymerase chain reaction testing results indicating the presence of *K. pneumoniae* carbapenemase genes.

[b] Tested using Etest.

Elemam A, et al. Clin Infect Dis 2009; 49:271-4

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- **Potential for spread into the community**
  - *E. coli* common cause of community infection

Multidrug-resistant GNRs in the Community

- **Extended-Spectrum β-lactamases (ESBLs)**
  - Reports of community-associated ESBL-producing *E. coli* infections in mid-2000s, initially mostly from Europe and Canada
  - US – 5 hospitals in different states in 2009-2010
    - Screened >13,000 *E. coli* isolates, 523 were ESBL-producing *E. coli*
    - 291 patients with community-onset* ESBL-producing *E. coli*
      - 107 (36.8%) were community-associated**
        - 82% were urinary tract infection
        - 54% were caused by globally epidemic ST131 strain
        - 91% produced CTX-M-type ESBL

*collected as outpatient or within 48 hrs of admission

**Was not hospitalized in previous 90 days, not resident of LTCF, did not receive IV therapy or visit dialysis clinic in previous 30 days

Doi Y et al. Clin Infect Dis 2013;56:641-8.

Multidrug-resistant GNRs in the Community

- **NDM**
  - Cause of community-onset infections in India
    - In one survey, isolates from 2 sites often from community acquired UTIs
  - Gene for NDM detected in 2/50 drinking water samples and 51/171 water seepage samples from New Delhi
  - Identified in *K. pneumoniae* in river in Hanoi, Viet Nam

Kumarasamy K Lancet ID 2010;
Walsh TR Lancet ID 2011:355-362
Isozumi R et al. EID 2012: 1383-4

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In most areas in the United States this organism appears infrequently identified and is limited to healthcare settings

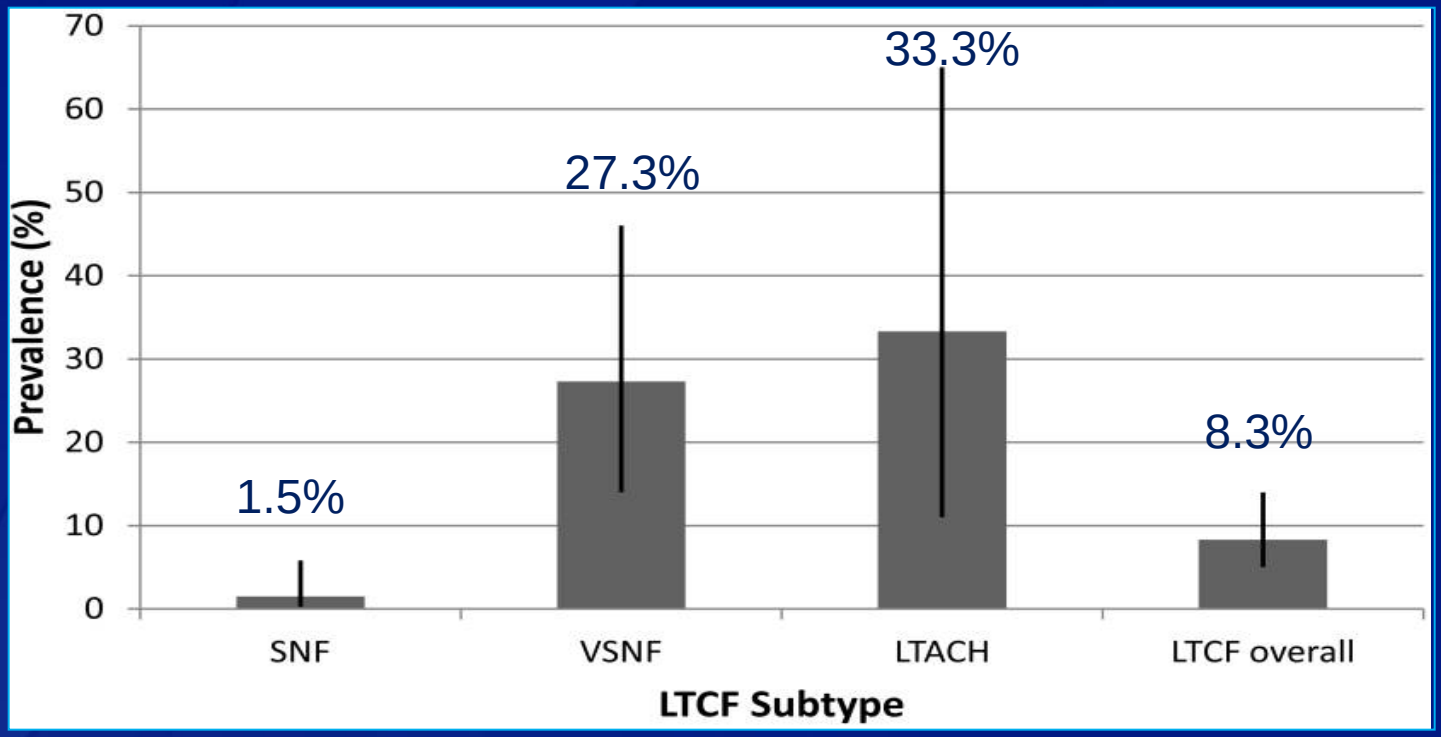
CRE in Long-Term Care Settings

- **Since 2004, reports of CRE cases from LTACH and LTCF**
- **Point prevalence surveys in Chicago in 2010, 2011**
  - 15 / 24 hospitals and 7 / 7 LTACHs had at least 1 KPC-colonized pt
  - 3.3% (30/910) ICU patients (24 hospitals) were colonized with KPC
  - 30.4% (119/391) LTACH patients were colonized with KPC
- **Potential for large reservoir of patients with CRE**
  - Multiple comorbidities
  - Concentrated in one location for extended period of time

Lin MY et al. CID 2013; 1246-52.

CRE Prevalence in LTCF: By Type

Prevalence of CRE Carriage at admission to 4 acute care hospitals



Prabaker K et al. ICHE 2012; 33:1193-1199

0% from those admitted from the community

CRE Outbreak — WV, 2009–2011

- **Health department notified of cluster of carbapenem-resistant *K. pneumoniae* (CRKP) at Hospital A**
- **19 cases identified**
  - 16 admitted from LTCFs, 14 from LTCF A
  - Majority of these 14 cases had positive culture ≤2 days of admission to Hospital A
- **Case-control study performed**
  - CRKP infection strongly associated with prior stay at LTCF A (OR=35)

MMWR 2011;60(41):1418-20.

WV CRE Outbreak

- **Point prevalence survey**
  - None of 29 Hospital A patient samples were positive
  - 11 (9%) of 118 LCTF A resident samples were positive
    - Including 8 residents with previously unrecognized CRKP colonization
- **Molecular typing**
  - PFGE performed on 5 Hospital A isolates + 11 LTCF A isolates
  - >88% similarity in PFGE patterns

MMWR 2011;60(41):1418-20.

Inter-Facility Transmission of MDROs (Including CRE)

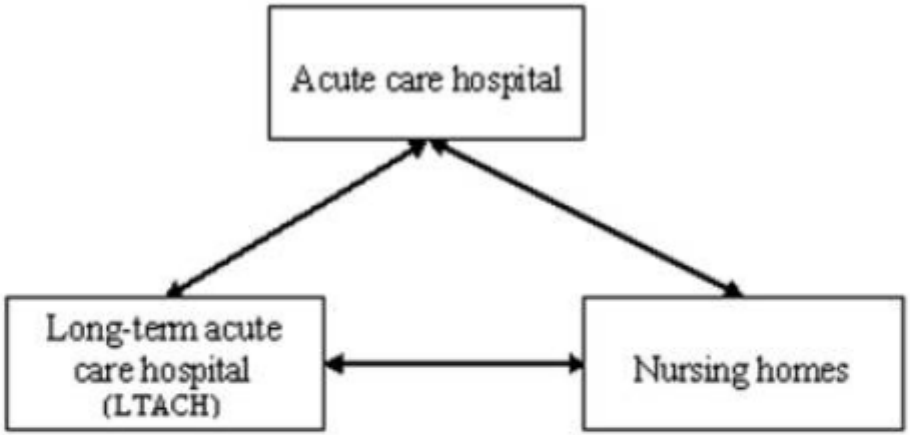
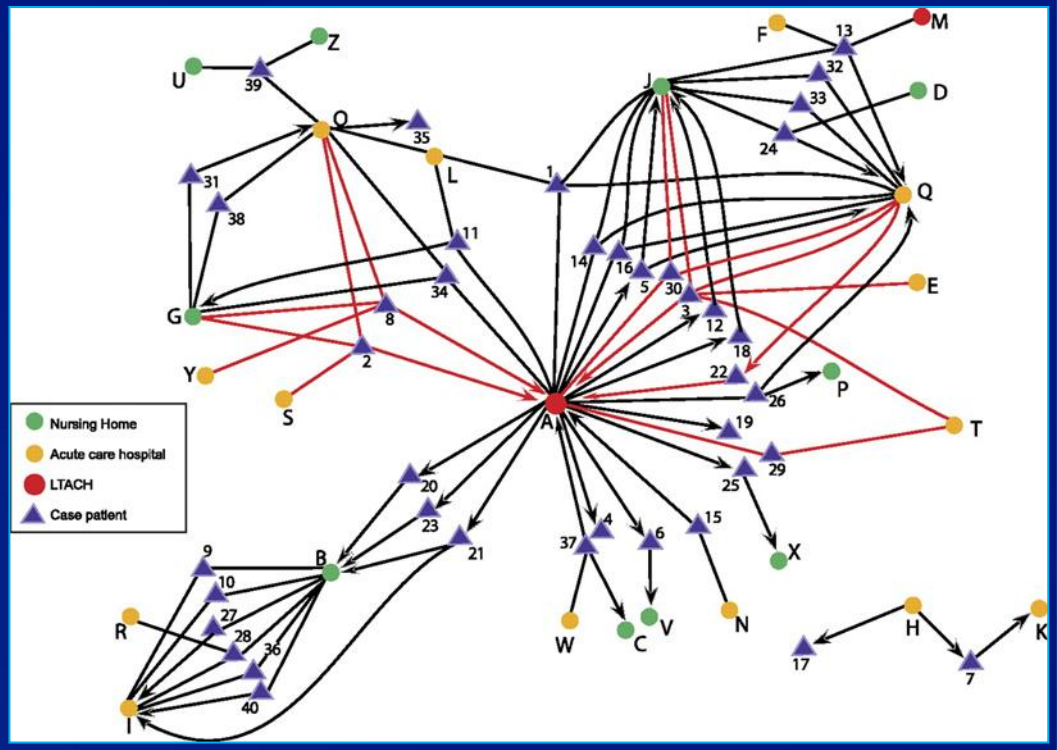


Figure 3. Patient flow among regional health care facilities. Outbreaks of infection with multidrug-resistant organisms have been found to follow the flow of colonized patients across institutions.

Munoz-Price SL. Clin Infect Dis 2009;49:438-43.

Outbreak of CRE with Regional Dissemination, Chicago Area, 2008

- **Extensive network of facilities: 14 acute care hospitals, 2 LTACHs, and 10 NHs**
- **40 patients with KPC-producing CRE**
  - 4 acquired in acute care setting
  - 24 (60%) linked to 1 LTACH



Won SY et al. Clin Infect Dis. 2011;53:532-40.

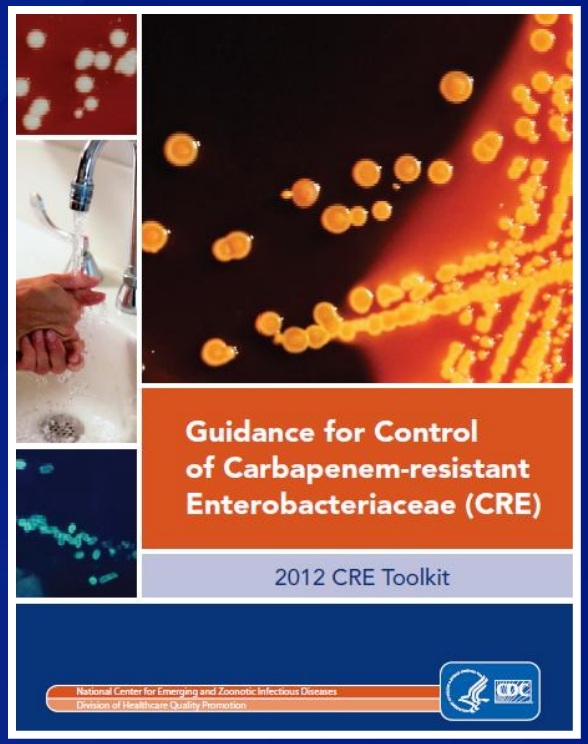
Implications for CRE Control

- **Earliest cases were not recognized by laboratory personnel and Infection Preventionists**
  - Education of healthcare personnel is critical
- **LTACHs and other LTCFs have major role in CRE amplification and dissemination**
  - Control efforts need to extend to LTCFs
- **Emergence of CRE in a single facility quickly becomes a regional problem**
  - Control of CRE will require a coordinated regional approach among all facilities

CRE PREVENTION STRATEGIES

CRE Toolkit

- Facility-level recommendations
- Regional prevention strategy for health department implementation



http://www.cdc.gov/hai/organisms/cre/cre-toolkit

Surveillance and Definitions

- **Facilities/Regions should have an awareness of the prevalence of CRE in their Facility/Region**
- **Could concentrate on select CRE**
  - *Klebsiella* spp., *E. coli*, *Enterobacter* spp.
- **One suggestion of a definition for carbapenemase-producing CRE (based on 2012 CLSI breakpoints):**
  - NS to one of the carbapenems (doripenem, meropenem, imipenem)
  - Resistant to all 3rd generation cephalosporins tested
  - Some Enterobacteriaceae are intrinsically resistant to imipenem (*Morganella*, *Providencia*, *Proteus*)

FACILITY-LEVEL CRE PREVENTION

Facility-Level Measures: Acute and Long-Term Care Facilities

- **Core**
  - Hand hygiene
  - Contact Precautions
  - HCP education
  - Minimizing device use
  - Patient and staff cohorting
  - Laboratory notification
  - Antimicrobial stewardship
  - CRE Screening
- **Supplemental**
  - Active surveillance cultures
  - Chlorhexidine bathing

Facility-Level Recommendations: Core Measures

Hand Hygiene

- **Educate staff with frequent in-services**
  - At orientation and periodically
- **Monitor hand hygiene adherence and provide feedback of performance**
- **Ensure access to hand hygiene stations**
  - Install alcohol-based hand gel dispensers in/near patient rooms
- **Encourage use of alcohol-based hand gel dispensers in favor of soap and water (exceptions include when hands are visibly soiled)**

Facility-Level Recommendations: Core Measures

Contact Precautions

- For patients colonized or infected with CRE
- Prioritize CP based on functional status of patients in long-term care settings
- Systems in place to identify patients at readmission
- Consider pre-emptive CP in patients transferred from high-risk settings
- Education of HCP about use and rationale behind CP
- Monitor adherence and provide feedback

Predictors of Persistent CRE Carriage on Readmission

- **Case-control study of 66 patients with CRE**
  - Compared those positive at readmission with those that were negative

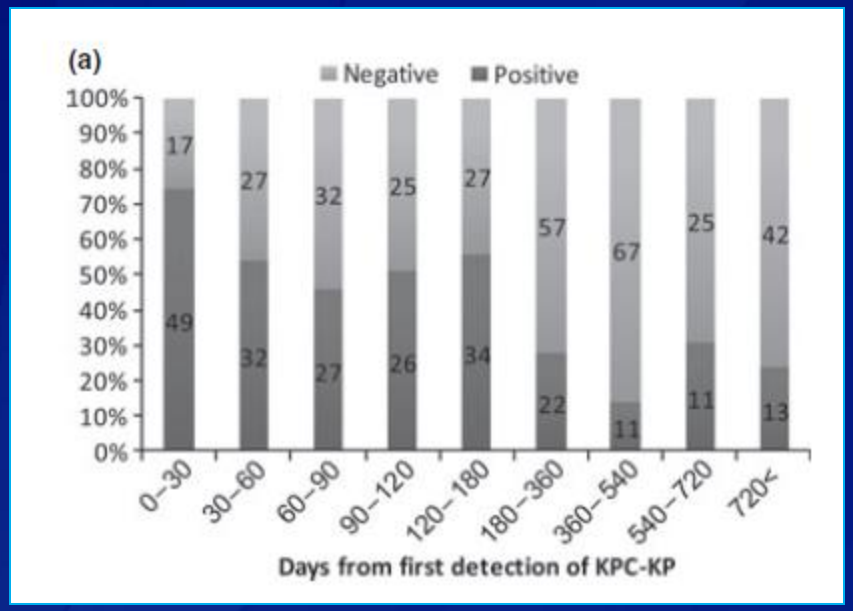
TABLE 2. Distribution of the Total Number of Predictors among Carbapenem-Resistant Enterobacteriaceae (CRE) Screen-Positive Case Patients and CRE Screen-Negative Control Patients and the Probability of Having a Positive Screen Test on the Basis of the Total Number of Predictors

No. of predictors	Positive screen test ($n = 23$)	Negative screen test ($n = 43$)	Probability of a positive screen test, % (95% CI)
0	4	24	14.3 (4.0–32.7)
More than 1	19	19	50.0 (33.3–66.7)

NOTE. Predictors included prior fluoroquinolone use (during the 30 days preceding the survey), transfer from an institution or another hospital, and time interval less than or equal to 3 months since the first CRE test. CI, confidence interval.

Schechner V et al. ICHE 2011;32:497-503

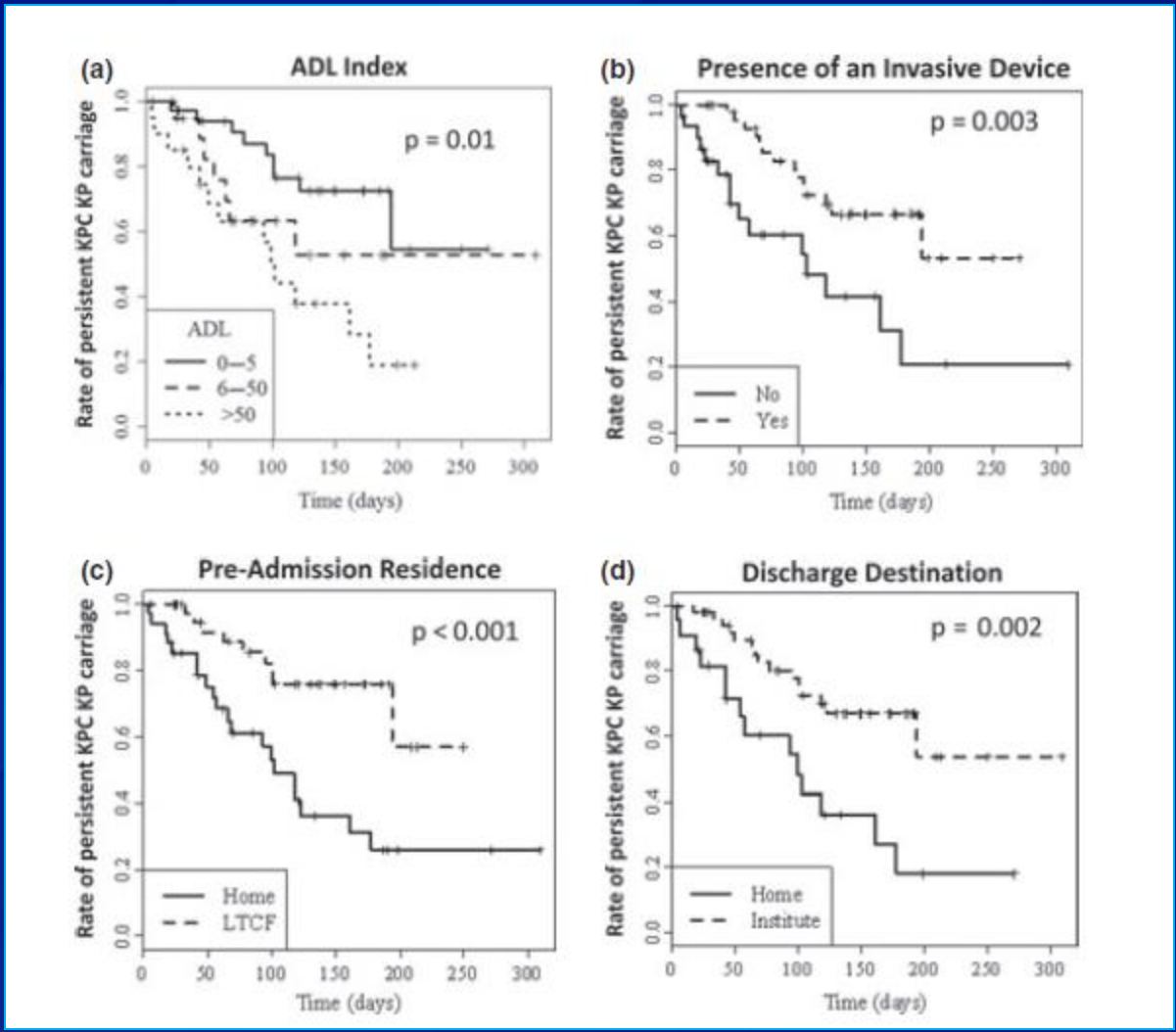
Duration of KPC Carriage



- KPC Patients swabbed 5 to 6 times (at discharge, 2 weeks, 1,2 3 mos post discharge)
- Overall resolution of carriage (2 consecutive negative)
  - 62/125 (52%)
  - 39% of recently identified patient
  - 72% of remotely identified patients (> 4 mos prior)

Feldman et al. Clin Micro and Infect 2012;19:E190-196

Risk factors for Persistent Carriage



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Number of Screens to Determine CRE Clearance

- ≥1 negative test:
  65 / 97 (67%) cleared
- ≥ 2 negative test:
  57 / 67 (85%) cleared
- ≥3 negative test:
  45 / 50 (90%)cleared

TABLE 2. Validity of different criteria for defining clearance of KPC KP carriage

Criteria[a]	Study group	Total number of patients, *n*	Patients with negative tests, *n*	Patients with KPC KP[b] clearance, *n* (%[c])
1		≥2 tests	≥1 negative test	
	REC[d]	69	54	29 (54)
	REM[e]	49	43	36 (84)
2		≥3 tests	≥2 negative tests	
	REC	55	31	25 (81)
	REM	42	36	32 (89)
3		≥4 tests	≥3 negative tests	
	REC	52	19	16 (84)
	REM	39	31	29 (94)

[a]Criteria, number of consecutive negative tests (without subsequent positive test) necessary for defining clearance of KPC KP carriage.
[b]KPC KP, KPC-producing *Klebsiella pneumoniae*.
[c]%, ratio of the number of patients with KPC KP clearance to the number of patients with negative tests.
[d]REC, recent (<4 months) KPC KP acquisition group.
[e]REM, remote (>4 months) KPC KP acquisition group.

Feldman et al. Clin Micro and Infect 2012;19:E190-196

Facility-Level Recommendations: Core Measures

HCP Education

- **Regular education about MDRO prevention**
  - Hand hygiene
  - Contact Precautions
  - Appropriate handling/care of invasive devices

Facility-Level Recommendations: Core Measures

Device Use

- **Minimize use of invasive devices**
- **Ensure implementation of CDC/HICPAC recommendations:**
  - Urinary catheters
  - Central lines

Facility-Level Recommendations: Core Measures

Patient and Staff Cohorting

- **Place CRE patients in single-patient rooms**
  - Preference for single rooms should be given to patients at highest risk of transmission (e.g., stool incontinence, have medical devices, open wounds)
  - If not available, place patients together in same room
- **Cohort CRE patients to specific areas (e.g., units or wards) with dedicated staff**

Facility-Level Recommendations: Core Measures

Laboratory Notification

- **Perform appropriate laboratory screening for CRE (in accordance with CLSI guidance)**
- **Have protocols in place for timely notification of appropriate staff when CRE are isolated**
  - Applies to on-site and off-site laboratories

Facility-Level Recommendations: Core Measures

Antimicrobial Stewardship

- **Programs to ensure:**
  - Antimicrobials used for proper indications and duration
  - Appropriate spectrum
- **Link to Get Smart for Healthcare:**
  - http://www.cdc.gov/getsmart/healthcare

Facility-Level Recommendations: Core Measures

CRE Screening

- **Used to identify unrecognized CRE colonization among high-risk patients (e.g., CRE contacts)**
  - Screening of epi-linked patients, e.g., roommates, patients who shared same HCP
  - Point prevalence surveys
    - Rapid evaluation of CRE prevalence in particular wards/units
    - Do once if few or no additional CRE colonized patients identified
    - Do serially if colonization more widespread and/or to follow effect of intervention
- **Typically obtain cultures of stool, rectal, or peri-rectal**
  - Link to laboratory protocol http://www.cdc.gov/ncidod/dhqp/pdf/ar/Klebsiella_or_E.coli.pdf

Risk for Transmission

- **Observational study: facility screened roommates of ESBL positive patients for evidence of transmission**
  - 133 roommates of ESBL positive patients, overall mean exposure period was 4.3 days
  - 2/133 (1.5%) confirmed transmission of same strain type: exposure time was 9 and 10 days
- **NDM outbreak in Canada: single facility over 15-month period**
  - 7 / 45 contacts had NDM (roommates, ward mates, environmental contact)
  - Exposure time was significantly longer for roommates who acquired NDM (26.5 days vs 6.7 days)

Tschudin-Sutter S et al. CID 2012;55:1505-1511
Lowe C et al. ICHE 2013;34:49-55

Facility-Level Recommendations: Supplemental Measures

Active Surveillance Cultures

- **Studies suggest that only a minority of patients colonized with CRE will have positive clinical cultures**
  - CRKP Point prevalence study in Israel (5.4% prevalence rate); only 5/16 carriers (31%) had a positive clinical culture for CRKP
  - A study of surveillance cultures at a US hospital found that they identified a third of all positive CRKP patients
    - Placing these patients in CP resulted in about 1400 days from unprotected exposure.

Weiner-Well et al. J Hosp Infect 2010;74:344-9
Calfee et al. ICHE 2008;29:966-8

Active Surveillance Cultures

- **Potential considerations:**
  - Focus on pre-specified high-risk patients (e.g., from LTCF/LTACH) or patients admitted to certain settings (e.g., ICU)
  - Generally done at admission but can also be done periodically throughout hospital course
- **Patients identified via surveillance cultures should be treated as colonized (i.e., Contact Precautions, etc.)**
- **Surveillance sites**
  - Rectal/stool swab appears to be most sensitive (68% to 97%)
  - Skin (e.g., inguinal, axillary) can also be colonized with CRE and can add to sensitivity if sampled

Thurlow C et al. ICHE 2013;34:56-61
Weiner-Well Y et al. J Hosp Infect 2010; 74:344-349

Facility-Level Recommendations: Supplemental Measures

Chlorhexidine Bathing

- **Has shown decreased transmission of MRSA and VRE**
- **Limited evidence for CRE**
  - Used effectively in few outbreaks as part of a package of interventions
- **If using CHG bathing**
  - Apply to all patients regardless of CRE colonization status
  - Perform daily for maximum benefit
- **MICs for GNRs might be higher than for Gram-positives**
- **Studies suggest CHG bathing may not be done "well"**
  - Neck area less thoroughly cleansed than other body sites

Munoz-Price et al. ICHE 2010;31:341-7
Palmore T et al. CID 2013; epub.
Popovich et al. ICHE 2012;33:889-96.

REGIONAL CRE PREVENTION

Regional Approach to MDRO (CRE) Prevention is Essential

- **Rationale for regional approach**
  - What happens in one facility will impact surrounding facilities
  - Individual facilities can reduce MDRO prevalence only to a certain point
- **Successful regional coordination by public health**
  - VRE control in Siouxland region
  - CRE containment in Israel

Sohn AH et al. Am J Infect Control 2001;29:53-7.
Schwaber MJ et al. Clin Infect Dis 2011;52:848-55.

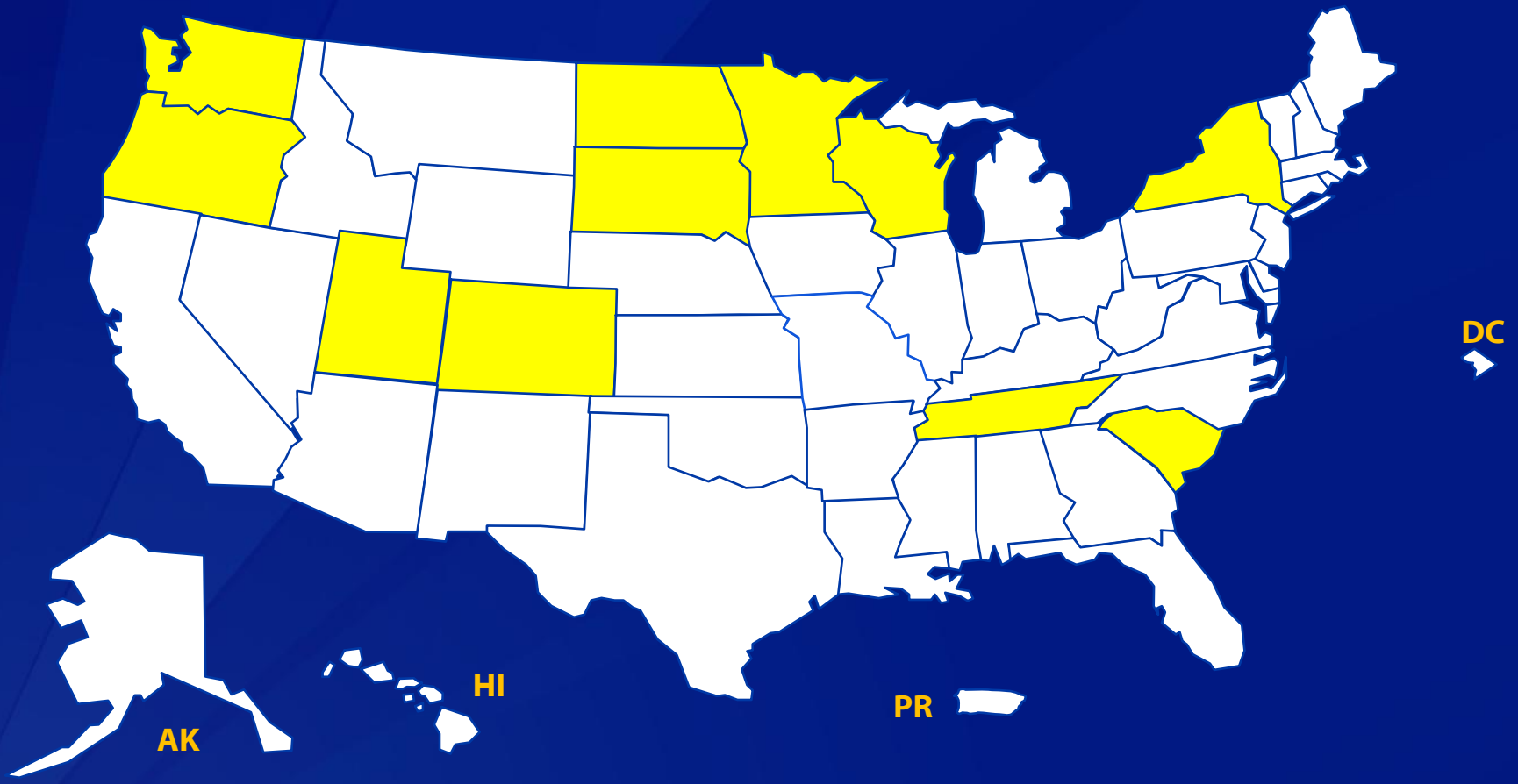
Regional CRE Prevention Strategy

- **Aggressive approach to contain or prevent CRE emergence**
  - Regions with no CRE identified
  - Regions with few CRE identified
- **Broad approach is required in regions where CRE are common**
- **Inter-facility communication during patient transfer**
  - Indicate CRE status, open wounds/devices, antimicrobial therapy and duration

Important Role of Public Health in CRE Control

- **Health departments in unique position to facilitate/support regional prevention efforts**
  - Provide situational awareness to facilities
  - Provide technical and laboratory support

CRE Mandatory Reporting (as of July 2013)



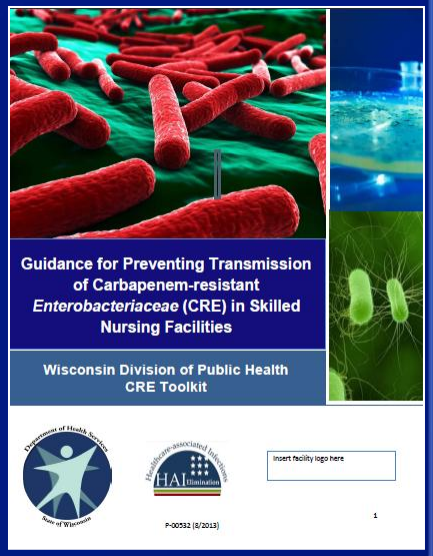
Illinois XDRO Registry

- **Partnership between IDPH and Chicago CDC Prevention EpiCenter**
- **November 1, 2013, Illinois healthcare facilities and laboratories will be required to report CRE to a registry**
  - Focusing on carbapenemase-producers
  - Manual entry now but eventually could have electronic entry and electronic notification
- **Will allow for:**
  - Improved CRE surveillance
  - Improved intra-facility communication

http://www.idph.state.il.us/rulesregs/2013_Rules/Adopted/77_IAC_690_6-19.pdf

Wisconsin

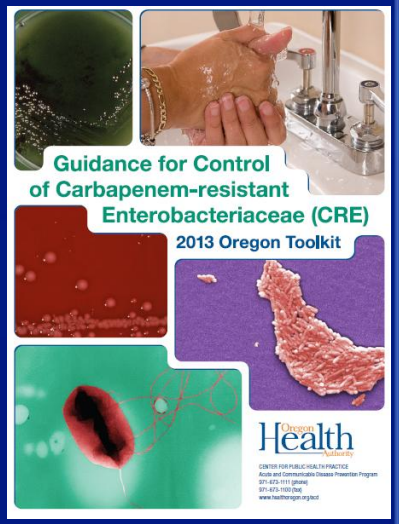
- **Follow up on every CRE case in the state**
  - Track patient movement across healthcare settings to ensure recommendations implemented
- **State partnership with City of Milwaukee Health Department to form regional collaborative**
  - Improve inter-facility communications
  - Establish consistent CRE prevention practices
  - Created WI CRE toolkits for acute care and long-term care facilities
    - Tiered approach based on whether CRE are carbapenemase producers



http://www.dhs.wisconsin.gov/publications/P0/p00532.pdf

Drug-Resistant Organism Prevention and Coordinated Regional Epidemiology Network (DROP-CRE)

- **Created toolkit specific for Oregon response**
- **Statewide education campaign**
- **Epidemiology of cases**
  - Complete medical record review of all cases
  - Track movement of cases between facilities
  - Report posted monthly to website
- **Rapid response**
  - Testing with PCR and modified Hodge test (MHT)
  - Carbapenemase-producers receive immediate assistance from DROP-CRE for response



http://public.health.oregon.gov/DiseasesConditions/DiseasesAZ/Pages/disease.aspx?did=108

Summary

- **Carbapenem-resistance among Enterobacteriaceae appears to be increasing**
  - Driven primarily by the emergence of carbapenemases
  - Associated with high mortality rates and limited treatment options
- **CRE transmission occurs across the continuum of care and has potential to spread more widely**
- **Heterogeneously distributed within and across regions**
  - Most areas are in a position to act to slow emergence
- **Regional approach is critical to CRE control**
  - Public health well-positioned to help coordinate regional response efforts

Thank you

For more information please contact Centers for Disease Control and Prevention

1600 Clifton Road NE, Atlanta, GA 30333
Telephone, 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348
E-mail: cdcinfo@cdc.gov Web: www.cdc.gov

National Center for Emerging and Zoonotic Infectious Diseases
Division of Healthcare Quality Promotion