National Center for Emerging and Zoonotic Infectious Diseases

Emerging Infectious Disease in the U.S.

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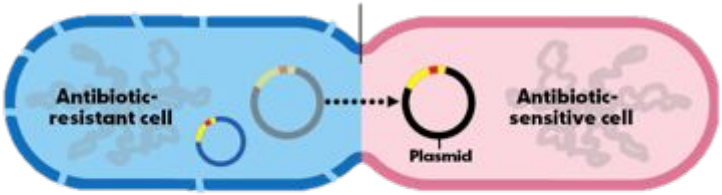
No Disclosures

With so many emerging diseases, why focus on antibiotic resistance?

- Antibiotic resistant (AR) germs avoid the effects of the drugs designed to kill them
  - Life-saving treatments depend on antibiotics that work
- AR affects all communities
- AR is not stoppable but its spread can be slowed
  - Easiest to control when problem is small/ emerging
  - New CDC initiatives designed to contain spread of AR

Historical Perspective

- Approximately 30 years ago, new resistance mechanism identified called Extended Spectrum β-Lactamases
  - Degrade penicillins and cephalosporins
  - Move between strains on mobile genetic element called plasmid
  - Plasmids carried resistance to multiple antibiotics



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  - Move between strains on mobile genetic element called plasmid
  - Plasmids carried resistance to multiple antibiotics
- No coordinated response or guidance for ESBL control
  - Now, ~20% of isolates from HAIs are resistant to cephalosporins
  - ESBLs are prevalent in the community

Overview

- Three high priority emergent organisms or resistance mechanisms
  - Carbapenemase producing organisms
  - *mcr-1*
  - *Candida auris*
- New tools and approach to controlling emerging resistant organisms

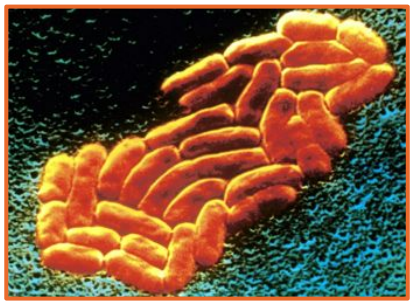
Emerging MDROs – Carbpanemease Producing Organisms

Gram-Negative Rods

- Encompass large number of pathogenic and non-pathogenic bacteria
- Glucose fermenters
  - Gut commensals and pathogens
  - Enterobacteriaceae: e.g., *Escherichia coli, Klebsiella pneumoniae, Salmonella enteriditis spp.*
- Glucose non-fermenters
  - Opportunistic pathogens
  - *Pseudomonas aeruginosa, Acinetobacter baumannii*
  - Intrinsically non-susceptible to many commonly used antimicrobials

Enterobacteriaceae

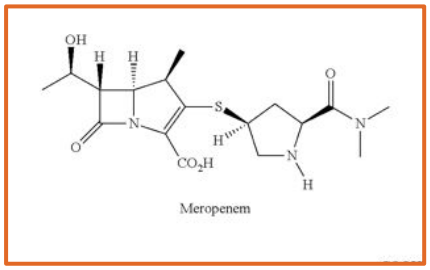
- Large family of gram negative rods with >25 recognized genera
- Most common family encountered in clinical microbiology labs
  - Most common are *Klebsiella* spp., *Escherichia coli*, and *Enterobacter* spp.
  - Also *Proteus*, *Providencia*, and *Morganella*
- Many are susceptible to many antibiotics including members of the penicillin family
  - Some have β-lactamases that lead to reduced susceptibility to penicillins



***K. pneumoniae*, scanning electron micrograph**
http://www.ppdictionary.com/bacteria/

Carbapenems

- Broad spectrum "antibiotics of last resort" for highly resistant infections
- Increasingly important due to emergence and spread of extended-spectrum β-lactamases (ESBLs) beginning in the 1990s
- Four approved carbapenems in US (imipenem, meropenem, doripenem, ertapenem)
  - Ertapenem less active against some bacteria, does not cover *Pseudomonas*



Meropenem

Carbapenem-Resistant Enterobacteriaceae (CRE)

- A.K.A. "Nightmare bacteria"
- Often multidrug resistant
- Cause infections with high mortality rates
- Multiple resistance mechanisms, two main types
  - Carbapenemase-producing CRE (CP-CRE)
  - Non carbapenemase-producing CRE (non CP-CRE)

Non-Carbapenemase Producing CRE (non CP-CRE)

- Often a combination of mechanisms contributes to resistance
- Chromosomal mutations such as porin loss combined with plasmid mediated mechanisms like Extended Spectrum β-lactamase (ESBL) or AmpC
- Can pass resistance vertically but not horizontally
- Often incur fitness defect

Carbapenemase-Producing CRE (CP-CRE)

- Carbapenemases are enzymes that digest carbapenems
  - Found in glucose non-fermenters in addition to Enterobacteriaceae
- Plasmid encoded
  - Can pass resistance vertically and horizontally
  - No/minimal fitness defect
- 5 carbapenemases of primary public health concern
  - *K. pneumoniae* carbapenemase (KPC) 🇺🇸
  - New Delhi Metallo-β-lactamase (NDM)
  - Oxacillinase (OXA-48-type)
  - Verona Integron Mediated Metallo-β-lactamase (VIM)
  - Imipenemase (IMP)
- Potential for epidemic spread

Spread of Carbapenemases Can Rapidly Increase Percent Resistant

- Examples of Spread
  - Israel: KPC outbreak
    - 11% carbapenem resistant in 2006
    - 22% carbapenem resistant in 2007
  - Greece: Dissemination of VIM
    - <1% carbapenem resistant in 2001
    - 20%-50% carbapenem resistant in 2006

Schwaber and Carmeli, JAMA. 2008;300(24):2911-2913. doi:10.1001/jama.2008.896
Vatopoulos, EuroSurveillance, Volume 13, Issue 4, 24 January 2008

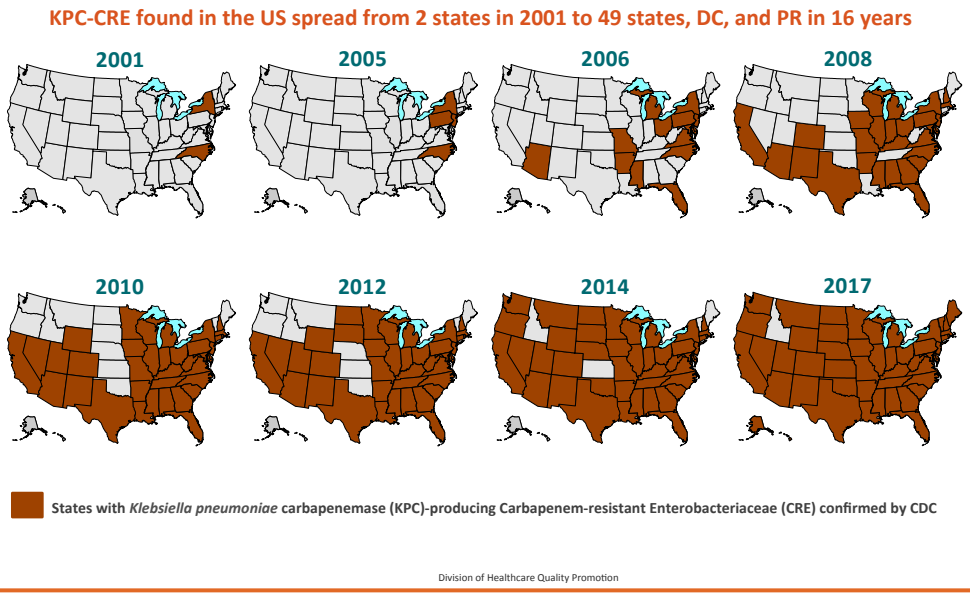
The US Experience: KPC

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]*

- Isolate collected in 1996 during an ICU surveillance project from NC



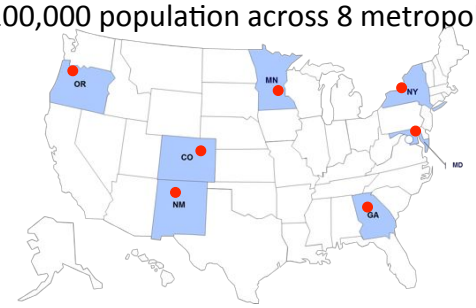
How Common are CRE in U.S. Hospitals?

- Among HAIs submitted to National Healthcare Safety Network (NHSN)
  - ~3-4% of Enterobacteriaceae NS to a carbapenem during 2011 to 2014
    - In 2001, only 1.2% NS to a carbapenem[1]
- In 2014, 7.8% of SSACH and 24% of LTACHs doing surveillance for CAUTI or CLABSI had at least one CRE infection[2]
- Facilities reported 0-13 LabID CRE Events per month in 2015[3]
  - High incidence states: mean 1.5 events/month
  - Low incidence states: mean 0.08 events/month

[1]Weiner, L. et al., Infect Control Hosp Epidemiol 2016;1–14
[2]Walters, M.. et al., SHEA, 2016
[3]Vasquez, A. et al., ID Week, 2016

CRE Population-Based Surveillance

- Emerging Infections Program Multisite Gram-negative Surveillance Initiative (MuGSI)
  - 8 U.S. sites
  - CRE from urine and normally sterile sites
- Incidence 2.93 per 100,000 population across 8 metropolitan sites[4]



Guh et al. JAMA, 2015;314(14):1479-1487.

MuGSI: CRE Epidemiology

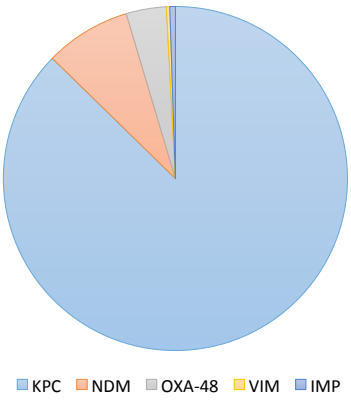
- 87% of cases from urine
- 33% from short stay acute care
- 75% had history of hospitalization in year prior
- 72% had indwelling device ≤2 days prior to culture
- 65% of case-patients hospitalized
  - 56% discharged to long term care facility

Guh et al. JAMA, 2015;314(14):1479-1487.

What Proportion of CRE are Carbapenemase Producers?

- Between January 1 and October 31, 2017, 3169 CRE were tested at state laboratories across the U.S.
  - 955 (30%) were carbapenemase-producers
  - 120 (13%) carbapenemases were non-KPC (e.g., NDM, VIM, IMP, OXA-48)
    - 28/59 (47%) with information available had healthcare outside the U.S. in 12 months prior

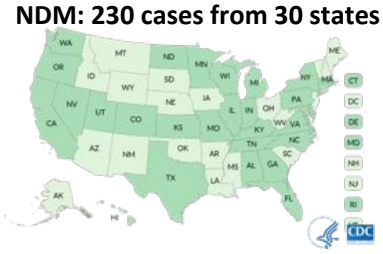
CP-CRE Reported through Antimicrobial Resistance Laboratory Network, January 1 – October 31, 2017



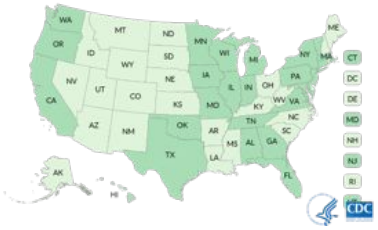
Data are preliminary and subject to change

Patients with non KPC CP-CRE reported to CDC as of June 2017

NDM: 230 cases from 30 states



OXA: 101 cases from 25 states



https://www.cdc.gov/hai/organisms/cre/trackingcre.html

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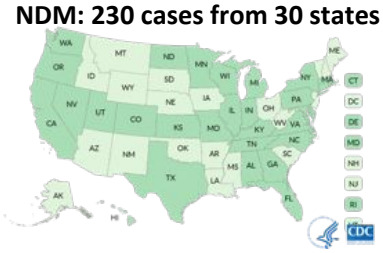
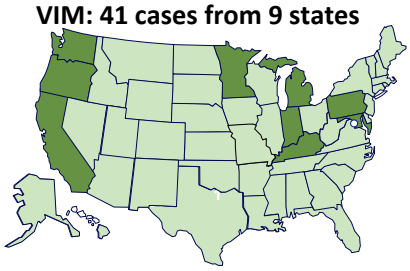
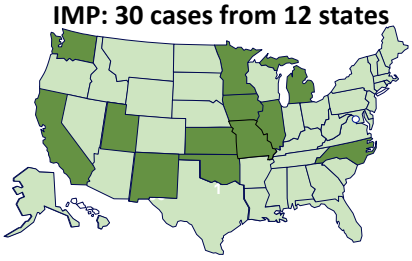


OXA: 101 cases from 25 states

VIM: 41 cases from 9 states



IMP: 30 cases from 12 states



https://www.cdc.gov/hai/organisms/cre/trackingcre.html

Is CP-CRE Limited to Healthcare Settings?

- EIP CRE surveillance: 10% of cases in persons without recent healthcare exposure
  - Primarily *E. coli* and *Enterobacter* in women presenting with UTI*
  - Some are CP-CRE

*CDC EIP unpublished data, preliminary and subject to change

Is CP-CRE Limited to Healthcare Settings?

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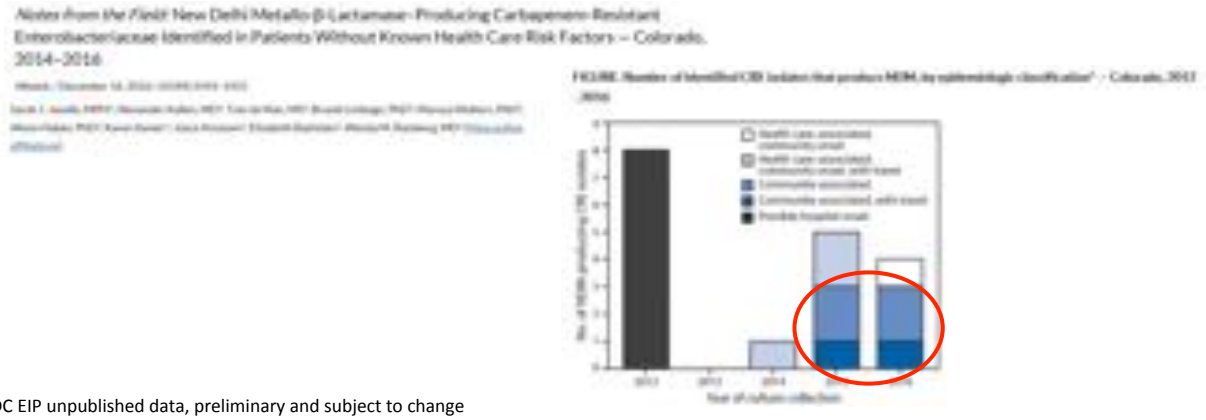
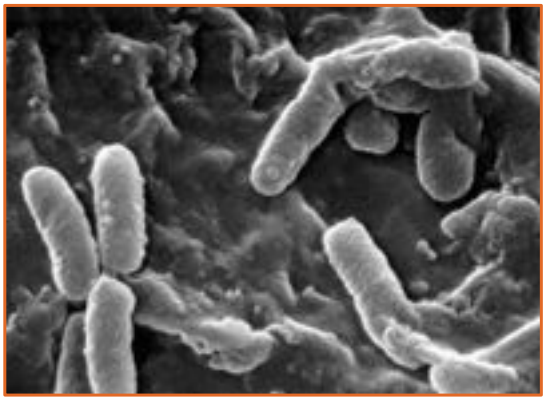
  - Primarily *E. coli* and *Enterobacter* in women presenting with UTI*
- Colorado: 6/10 recent NDM community-associated



*CDC EIP unpublished data, preliminary and subject to change

Carbapenemases in Glucose Non-Fermenters

- Primarily in *Pseudomonas*, also *Acinetobacter* and *Achromobacter*
- Carbapenemase-producing Pseudomonas common in some parts of the world
  - Brazil 1998-2012: 39% of CRPA
  - Europe 2009-2011: 20% of CRPA
  - Denmark 2011: 7% of CRPA

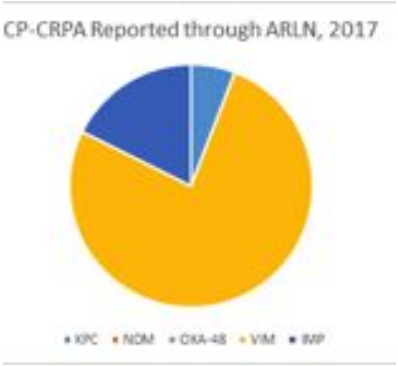


Scanning Electron Micrograph of *P. aeruginosa*, CDC

Hansen, F., *Microbial Drug Resistance*, 2014, 20(1):22-29
Rizek, C., *Annals of Clinical Microbiology,* 2014, 13: 43
Castanheira, M., *J. Antimicrob Chemother*, 2014, 69: 1804-1014

CP-*Pseudomonas* and *Acinetobacter* Extremely Rare in U.S.

- Between January 1 and October 31, 2017, 1117 CRPA were submitted to Antimicrobial Resistance Laboratory Network
  - 17 CRPA (1.5%) carbapenemase-producers
  - 16 (92%) of carbapenemases were non-KPC (e.g., NDM, VIM, IMP)
    - VIM most common
  - CP-CRPA often extremely resistant
    - Resistant to newer drugs: ceftolozane-tazobactam, ceftazidime-avibactam
    - Susceptible only to colistin
- Few CP-*Acinetobacter*, all NDM



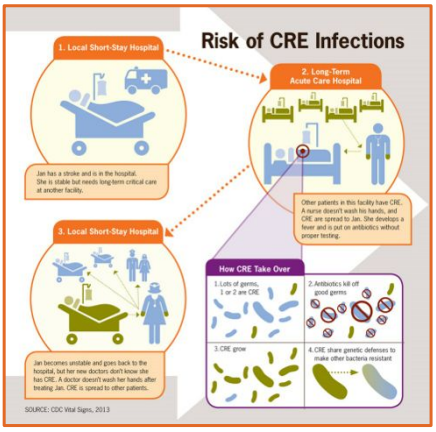
Data are preliminary and subject to change

CP-*Pseudomonas* Outbreaks

- Several large outbreaks of CP-*Pseudomonas*
  - VIM and IMP
  - Long term acute care hospitals and ventilator units of skilled nursing facilities
  - Longer length of stay units of short stay acute care hospitals

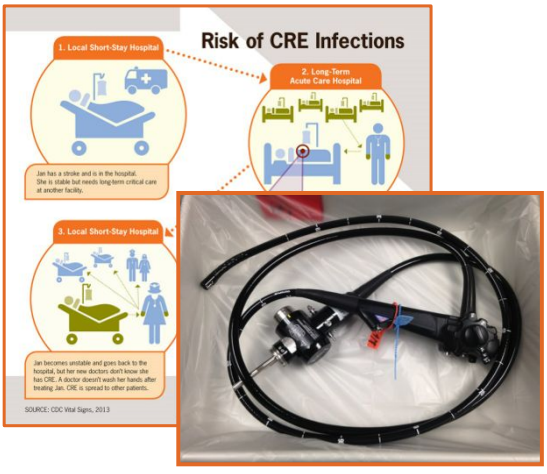
How Do CP-Organisms Spread in a Healthcare Facility?

- On the hands and clothes of healthcare workers
  - Long length of stay
  - High acuity of care
  - LTACHs and high acuity LTCF units highest risk



How Do CP-Organisms Spread in a Healthcare Facility?

- On the hands and clothes of healthcare workers
- Through inadequately reprocessed devices

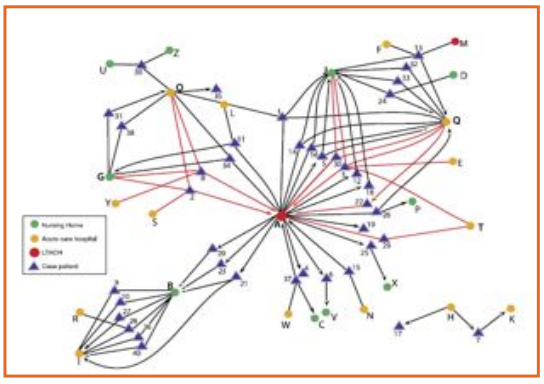


How Do CP-Organisms Spread in a Healthcare Facility?

- On the hands and clothes of healthcare workers
- Through inadequately reprocessed devices
- Through hospital sink drains and hoppers that become colonized with CP-CRE and contaminate patient supplies or environment

How Do CP-Organisms Spread in a Region?

- When transmission occurs undetected
- When patient's MDRO status is not communicated during interfacility transfer



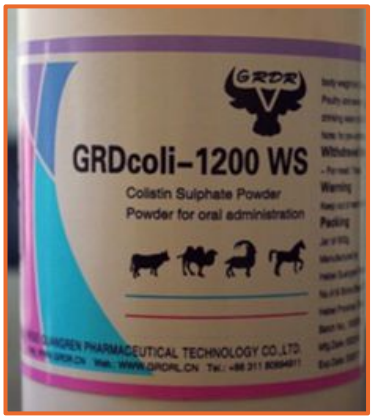
KPC outbreak in Chicago, 2008

Won et al. Clin Infect Dis 2011; 53:532-540

Emerging MDROs – colistin resistance and *mcr-1*

Polymyxin Antibiotics

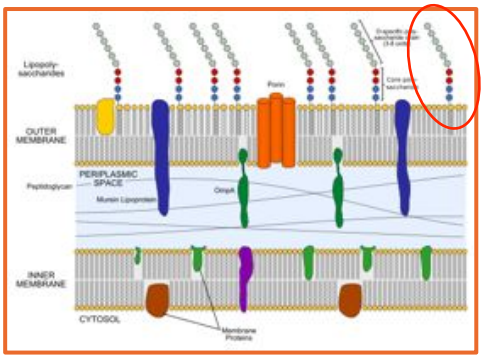
- Colistin (polymyxin E) and polymyxin B
- Used to treat serious, highly resistant infections
  - Broad activity against gram negative bacteria
  - Available in U.S. in topical and IV formulations
  - IV use associated with toxicities
- Used outside of the U.S.
  - Orally for selective digestive decontamination
  - Widely in veterinary medicine, especially animal agriculture



www.alibaba.com

Colistin Resistance

- Chromosomal resistance well-documented
  - Colistin binds lipopolysaccharide
  - Resistance through Lipid A modification
  - ~11% of ESBLs tested at CDC have colistin MIC ≥4 µg/ml
- Plasmid-mediated resistance first reported in November 2015 in China*
  - *mcr-1*: mobile colistin resistance
  - *E. coli* (primarily) and *K. pneumoniae*
  - Meat, animal isolates, clinical isolates



www.bio101.info

*Liu, *Lancet Infet Dis* 2016; 16: 16-68

Colistin Susceptibility Testing

- Multiple methodological issues and technical challenges
  - No FDA-cleared automated testing methods
  - E-test underestimates MIC by 1-2 doubling dilutions
  - Disk diffusion does not work due to poor diffusion
- ASM 2016: Laboratories that choose to test for colistin susceptibilities for clinical decisions should use broth microdilution
  - Only 1% of hospital labs in U.S. have this capacity
  - Might need to have reference labs perform this testing

Emergence of *mcr-1*

- Since initial report, found globally
  - >20 countries and 6 continents
  - Food animals, meat, vegetables, surface water
  - Ill patients, asymptomatically colonized patients
- Multiple species: *E. coli, K. pneumoniae, Salmonella enterica, Shigella sonnei*
- Earliest isolates identified from 1980s (chickens, *E. coli*, China)
- Earliest human isolate from 2008 (*Shigella sonnei*, Vietnam)

Liu, *Lancet Infet Dis* 2016; 16: 16-68
Skov, *Euro Surveill* 2016; 21(9):pii=30155

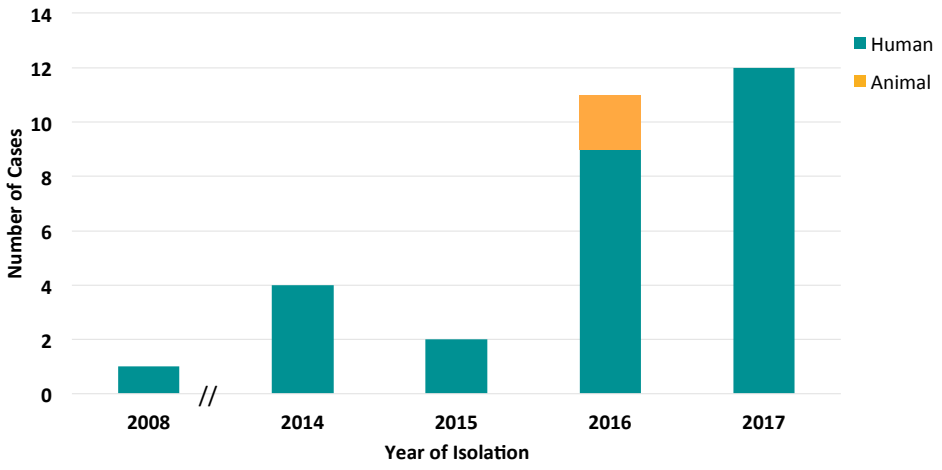
Molecular features of *mcr-1*

- Highly transmissible
  - In laboratory experiments among *E. coli, K. pneumoniae* and *P. aeruginosa*
  - Stably maintained in absence of polymyxin drug pressure
  - Potential for movement and rapid spread through epidemic clones
- Increased colistin MICs 8 to 16-fold
  - Typical MICs 4 to 8 µg/ml
- Other mobile colistin resistance mechanisms identified
  - 5 closely related variants *mcr-1.2* to *mcr-1.7*
  - 4 homologs *mcr-2* to *mcr-5*

Surveillance for *mcr-1* in the U.S.

- Retrospective surveillance
  - U.S. Government: National Antimicrobial Resistance Monitoring System (NARMS; retail meat, animal, clinical); DHQP reference and surveillance isolates; National Center for Biotechnology Information
  - Academia and private labs: SENTRY, Rutgers
- Prospective surveillance
  - CDC HAN, June 2016: Send Enterobacteriaceae with colistin MIC ≥4 µg/ml to CDC for mechanism testing
  - Sequencing all *Salmonella* spp.
  - Walter Reed Army Institute of Research MDRO Surveillance Network
  - Special surveillance project at 7 regional laboratories

Emergence of *mcr* in the U.S., n=30



mcr Cases by Location, as of November 1, 2017, n=30

https://www.cdc.gov/drugresistance/tracking-mcr1.html

U.S. *mcr-1* Cases

- 26 cases identified as of August 31, 2017 – 24 *mcr-1*, 2 *mcr-3*
- 14 *E. coli* (1 STEC), 10 *Salmonella*, 2 *Klebsiella pneumoniae*
- 22/26 had international travel in year prior
  - Dominican Republic (n=6), Vietnam (n=3), Cambodia (n=2), China (n=2), Mexico (n=2), Bahrain, Columbia, Jamaica, St. Vincent, Bahamas, Lebanon, Portugal, Thailand
  - Many had traveler's diarrhea
  - 2 were hospitalized outside the U.S.
- 9 had hospitalization in the U.S. in year prior to positive
  - 1 potential transmission in healthcare

mcr-1 Isolate Susceptibilities, Among Isolates Characterized Prior to December 31, 2017, N=9

	ESBL	Carbapenemase	Colistin MIC	Ceftriaxone	Ceftazidime	Cefepime	Imipenem	Ertapenem	Doripenem	Meropenem	Tmp-Smx	Ciprofloxacin	Levofloxacin	Gentamicin	Tobramycin	Amikacin	Aztreonam	Piptazo	Ampicillin	Tigecycline	Amp-sulbactam
E. coli[#]	Y	Y	3	R	R	R	R	R		R	S	R	R	S		S	S	R	R	S	R
E. coli	Y	N	4	R	R	R	S	S		S	R	R	R	R	R	S	R	S	R		
E. coli	Y	N	8	R	R	R	S	S	S	S	R	R	R	S	S	S	R	R	R	S	
E. coli	Y	N	4	R	R	R	S	S	S	S	R	R	R	S	I	S	R	S	R	S	
E. coli	Y	N	4	R	S	S	S	S			R	R	R	S	S		I	R	R		I
E. coli	Y*	N	2^	R	R	S	S	S	S	S	S	R	R	S	S	S	I	S	R	S	
E. coli	N	N	8	S	S	S	S	S		S	R	R	R	S	S	S	S	S	R	S	
Salmonella Enteriditis	N	N	8	S	S	S	S	S	S	S	S	I	I	S	S	S	S	S	S	S	S
Salmonella Typhirium	NT	NT	4	S	S	S	S	S	S	S	R	I	I	S	S	S	S	S	R	S	I

[#] E-test for Colitin; MicroScan for all others
* AmpC
^ Polymyxin B MIC = 4

S = Susceptible
I = Intermediate
R = Resistant
Not tested

Emerging MDROs – *Candida auris*

Candida auris

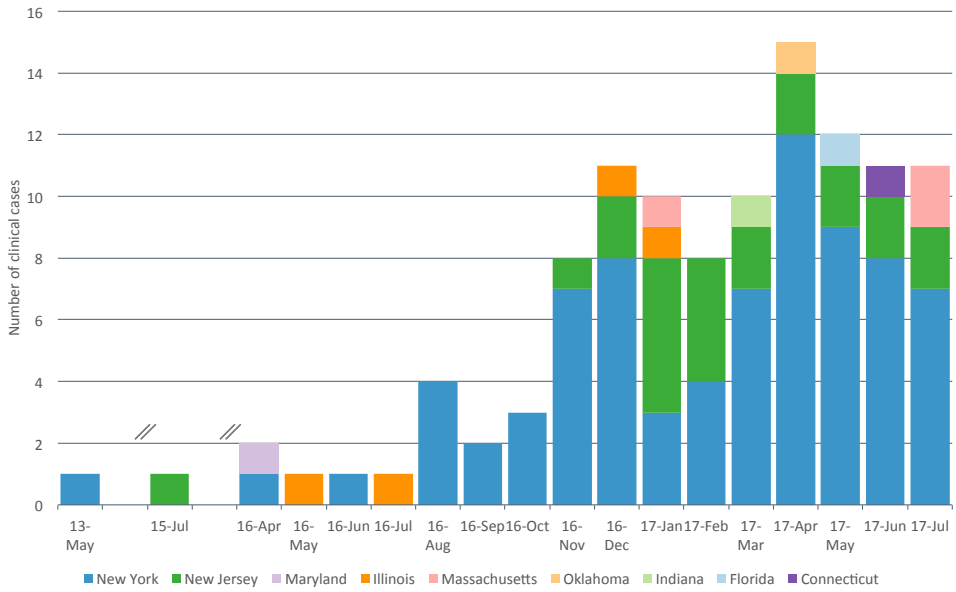
- Fungus that causes invasive infections with high mortality (60%)
- Explosive global spread since discovery in Japan in 2009
  - No *C. auris* in >7000 *Candida* isolates collected in U.S. 2008 –2016[1]
  - >30,000 *Candida* isolates collected from 4 continents, 1996-2015[2]
    - No *C. auris* before 2009
- Unlike most other *Candida* species
  - Colonizes skin
  - Transmitted person-to-person in healthcare
  - High level resistance
  - Difficult to identify in laboratory

[1]CDC EIP Candidemia surveillance
[2]SENTRY and ARTEMIS programs

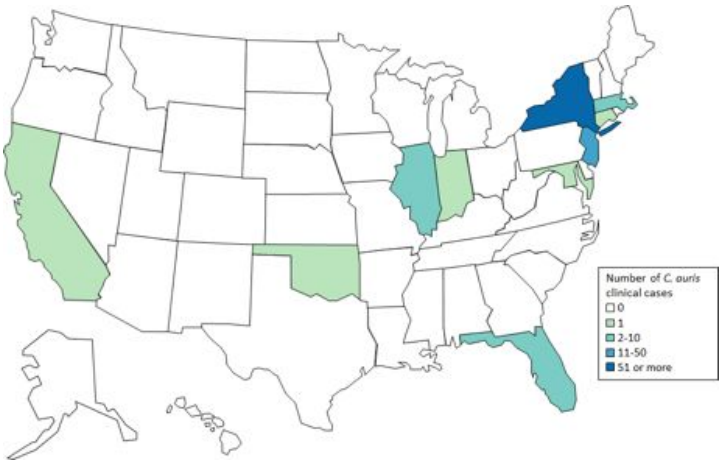
Global *C. auris* situation, September 30, 2017

https://www.cdc.gov/fungal/diseases/candidiasis/tracking-c-auris.html

C. auris cases reported by state — United States, 2013–July 2017, n=137



C. auris clinical cases reported by state, United States, September 30, 2017, n=137



An additional 184 asymptomatically colonized patients have been identified in four states with clinical cases.

C. auris is highly resistant

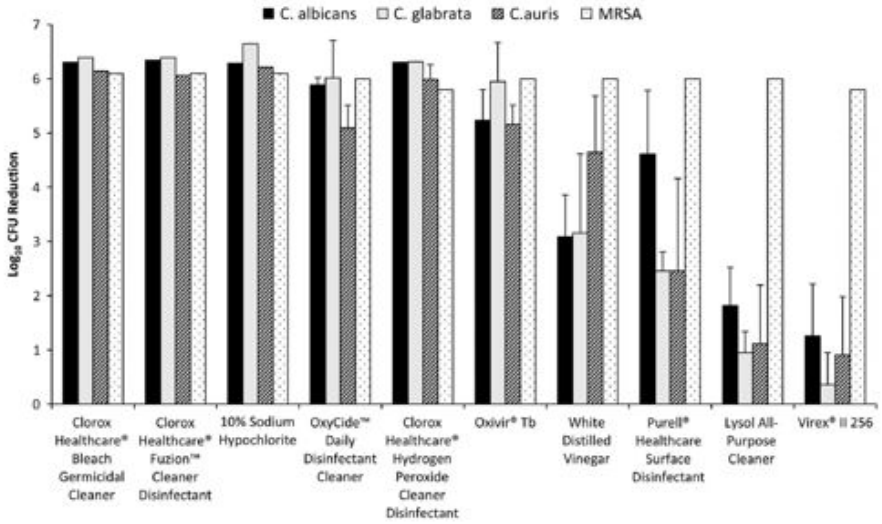
	Polyenes	Azoles	Echinocandins
			
C. glabrata	<1% resistant to amphotericin B	11% resistant to fluconazole	Up to 12% resistant to echinocandins
C. auris	35% resistant to amphotericin B	93% resistant to fluconazole 54% resistant to voriconazole	7% resistant to echinocandins

A few isolates resistant to all three classes

	Polyenes	Azoles	Echinocandins
			
C. glabrata	<1% resistant to amphotericin B	11% resistant to fluconazole	Up to 12% resistant to echinocandins
C. auris	35% resistant to amphotericin B	93% resistant to fluconazole 54% resistant to voriconazole	7% resistant to echinocandins

C. auris contaminates the hospital environment

Infection control: List K agents recommended for cleaning and disinfection



Cadnum et al. 2017

Candida auris is difficult to identify

Identification Method	Organism *C. auris* can be misidentified as
Vitek 2 YST	*Candida haemulonii* *Candida duobushaemulonii*
API 20C	*Rhodotorula glutinis* (characteristic red color not present) *Candida sake*
BD Phoenix yeast identification system	*Candida haemulonii* *Candida catenulata*
Microscan	*Candida famata* *Candida guilliermondii* (no hyphae/pseudohyphae present on cornmeal agar) *Candida lusitaniae* (no hyphae/pseudohyphae present on cornmeal agar) *Candida parapsilosis* (no hyphae/pseudohyphae present on cornmeal agar)

Please note that this list is based on current knowledge about C. auris misidentification. It may change from time to time as we learn more about misidentification of C. auris.

Detailed algorithms for identification are available on CDC *C. auris* page

https://www.cdc.gov/fungal/diseases/candidiasis/recommendations.html

Summary: Novel MDROs

- Highly transmissible resistance mechanisms or organisms
  - Plasmid mediated (CRE, *mcr-1*)
  - Skin colonization, persistent environmental contamination (*C. auris*)
- *C. auris* and non-KPC carbapenemases initially associated with recent hospitalization outside the U.S. and importation
  - Now transmission in the US
  - Possible spread to community (carbapenemase-producing organisms)
- *mcr-1*: primarily international travel without healthcare
  - Concern for spread in healthcare settings with more resistant bacteria and greater drug pressure
- Long length of stay, high acuity facilities and units can serve as amplifiers

Key Infection Control Actions for Novel MDROs

- Timely, accurate detection
- Notify patients of their results
- Educate healthcare personnel and visitors
- Meticulous adherence to hand hygiene and transmission-based precautions
- Environmental cleaning
  - Using List K agent for *C. auris*
- Interfacility notifications when transferring patients
  - If present at admission notify transferring facility
- Flag patient record to ensure appropriate precautions if readmitted
- Public health investigations to identify and stop transmission

New Tools and Approaches: Containment Strategy

Why are new strategies needed?

- MDROS have previously spread unchecked due to
  - Limited capacity to detect target organisms/mechanisms
  - Expense and lack of availability of screening
  - No guidance for response
- Improved detection, infection control, and identification of asymptomatic carriage can slow the spread of carbapenemase-producing organisms
- Slowing spread of resistance buys time for development of new drugs, novel therapies

Containment Strategy

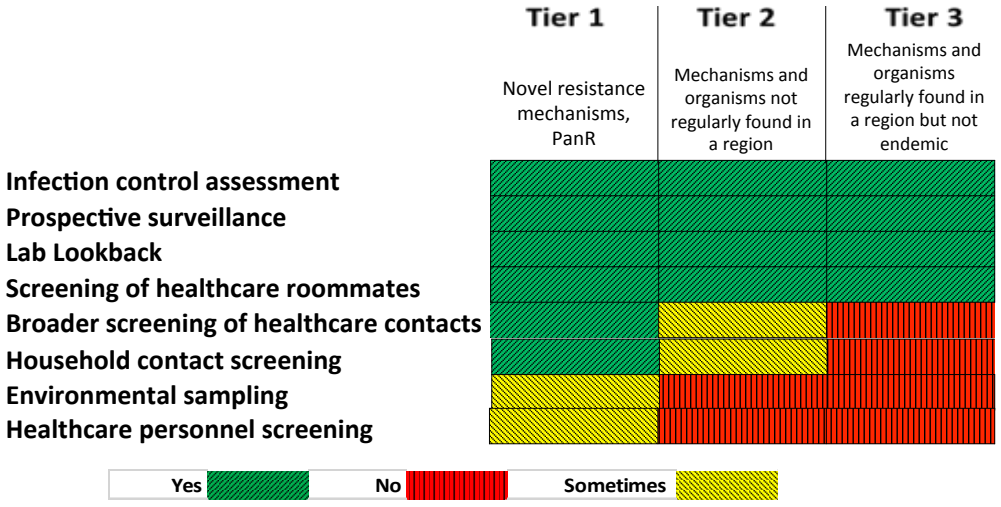
- Systematic approach to slow spread of novel or rare multidrug-resistant organisms or mechanisms through aggressive response to ≥1 case of targeted organisms
  - Carbapenemase-producing organisms, *mcr-1*
  - Pan-resistant organisms
  - *Candida auris*
- Emphasis on settings that historically are linked to amplification
  - Long term care facilities (e.g., skilled nursing)
  - Long term acute care facilities and high acuity skilled nursing (e.g., vSNF)

Containment Approach

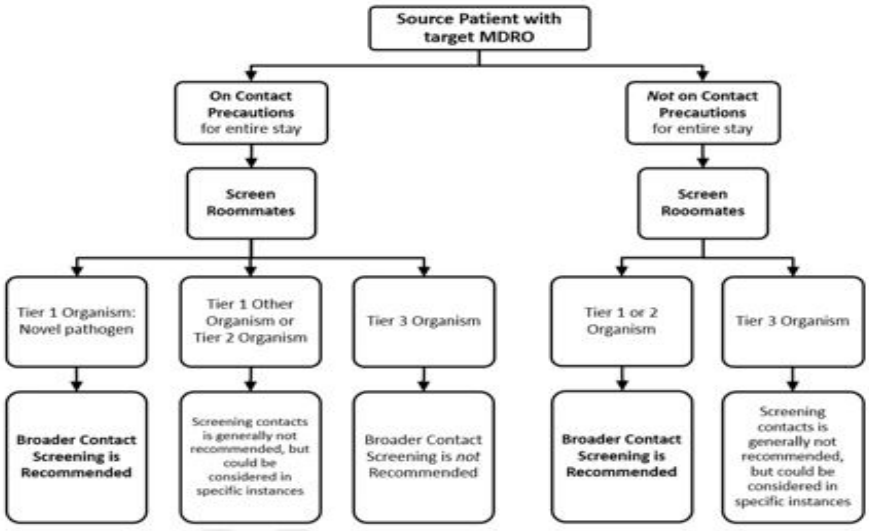
- Main components
  - Detection
  - Infection control assessments
  - Screening for asymptomatic colonization
- Response tiers based on pathogen/ resistance mechanism
- Guidance document available on CDC website
- Complements existing guidance
  - CRE Toolkit
  - VRSA Investigation Guide

https://www.cdc.gov/hai/outbreaks/mdro/index.html

Containment Response Matrix

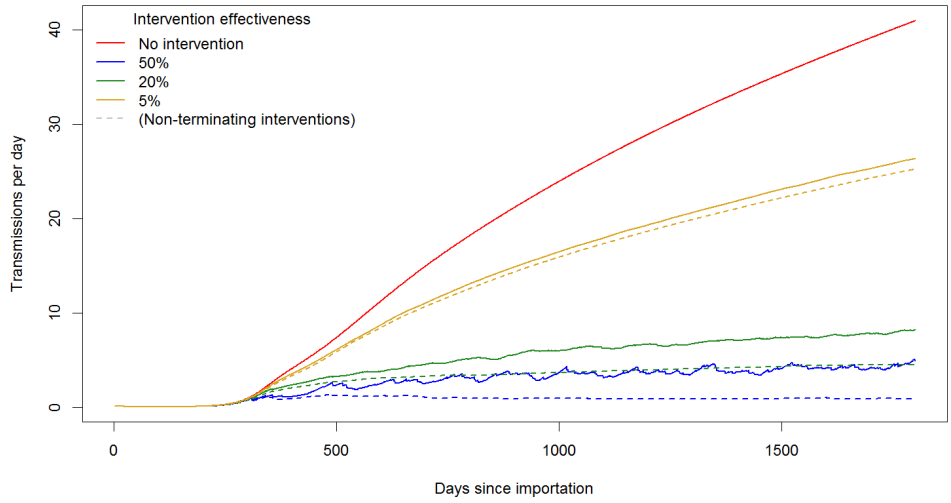


Approach to screening healthcare contacts



https://www.cdc.gov/hai/outbreaks/mdro/index.html

Simulating containment interventions



Courtesy of Prabasaj Paul and Rachel Slayton

New Tools and Approaches: Improved Detection & Access to Screening

Implementation of Containment: HAI/AR programs in every state

- In 50 states, 6 cities and Puerto Rico
  - Local AR/HAI expertise and support for systematic infection control assessments
  - Lab capacity to improve identification and response to emerging AR threats
    - Carbapenemase testing for Enterobacteriaceae and *Pseudomonas spp.*
- Expanded capacities at 7 regional labs
  - Carbapenemase-producing organism screening
  - *mcr-1* testing (targeted surveillance)
  - *C. auris* confirmatory testing

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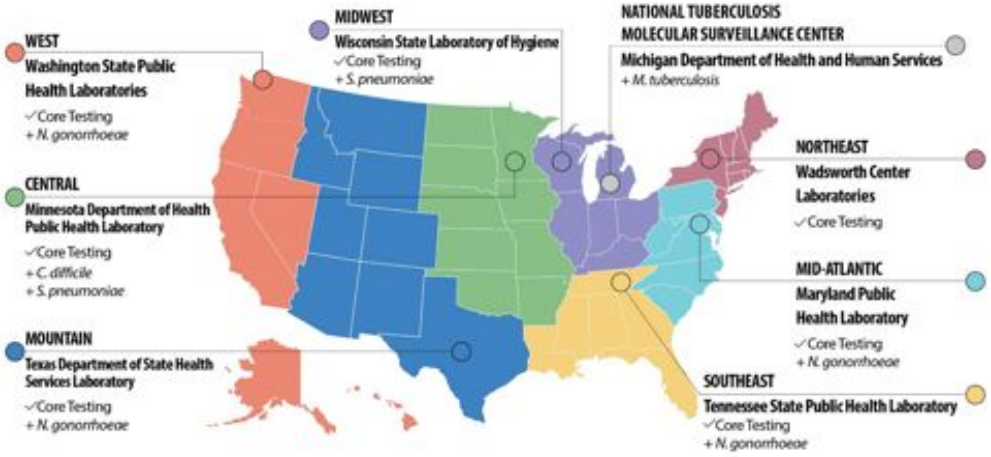
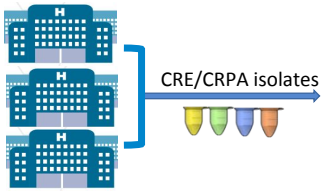
Antimicrobial Resistance Laboratory Network (ARLN)



ARLN Support for Containment - Detection

Hospitals/Clinical Laboratories



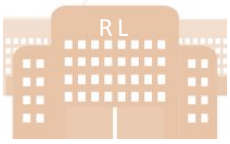
Public Health Laboratories
50 States
5 Local Health Departments

Species identification
Confirmatory AST
Phenotypic screening for carbapenemase production
Carbapenemase mechanism testing
mcr-1 testing (some labs)

ARLN Support for Containment – Contact Screening

Swabs from CP-CRE+ patient contacts

Swabs positioned regionally for rapid deployment to facilities where screening taking place



Rapid PCR-based detection from swab (Cepheid)

Regional lab

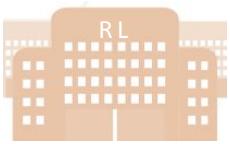
ARLN Support for Containment – Contact Screening

Provide or request assistance; Initiate investigation

Report within 1 working day of results

Swabs from CP-CRE+ patient contacts

Report within 1 working day of results



≤1 day turnaround

Regional lab

ARLN Support for Containment – Detection and Screening for patients with known risk factors

Following increased reports of non-KPC CRE, CDC now also recommends the following for patients with a history of an overnight stay in a healthcare facility (within the last 6 months) outside the United States :

- When a CRE is identified, test to determine the carbapenem resistance mechanism
- Consider each of the following:
  - Perform rectal screening cultures to detect CRE colonization.
  - Place patients on Contact Precautions while awaiting the results of these screening cultures.

State public health lab

Regional lab

Summary – New Approach and Resources

- "Containment" approach represents a more aggressive response to novel MDROs
  - Facilitated by Public Health
  - Tiers have flexibility to reflect regional epidemiology (e.g., KPC may be Tier 2 in some states and Tier 3 in others)
  - Goal is to slow spread through identification and isolation, infection control interventions, and identification of transmission
- New resources available for facilities: Guidance, infection control support, AST/ Resistance mechanism testing, colonization screening
- Successful containment requires collaboration among many players
  - CDC, State and local health departments, facilities across the continuum of care, clinical and public health laboratories

Thank you!

Contact:
MSWalters@cdc.gov

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  - Antimicrobial Resistance Laboratory Network
    - Allison Brown
- CDC Mycotic Diseases Branch
    - Snigdha Vallabhaneni

Summary: Novel MDROs - Resources

- CDC CRE Toolkit: https://www.cdc.gov/hai/organisms/cre/cre-toolkit/index.html
- CDC HAN for mcr-1: https://emergency.cdc.gov/han/han00390.asp
- *Candida auris* Interim Recommendations for Healthcare Facilities and Laboratories
  - https://www.cdc.gov/fungal/diseases/candidiasis/recommendations.html
- *C. auris* Reporting: candidaauris@cdc.gov