Best Practices for Surveillance of Antimicrobial Resistance via Electronic Laboratory Reporting
Recommendations from the CSTE AR/ELR Working Group, June 2017

Many surveillance initiatives, such as monitoring new and reemerging antimicrobial resistance (e.g., Carbapenem-Resistant Enterobacteriaceae (CRE)), are conducted entirely based on laboratory observation findings and are only made possible through electronic laboratory reporting (ELR), since manual data collection processes are too resource intensive. In November 2016, CSTE convened an AR/ELR Workgroup to focus on best practices and issues related to capturing CRE in HL7 2.5.1 standard format for reporting purposes to Public Health Agencies (PHA).

The purpose of this document is to capture AR/ELR workgroup members' experience with receiving and processing CRE ELRs from laboratories and recommend related best practices for working with laboratories and CRE ELR messages. This document focuses on laboratory reporting only; reporting from providers is outside of its scope. PHAs are the primary audience for these best practices, but many recommendations are closely tied to laboratory systems and practices and may be applicable to those settings. Although the focus of the workgroup is on CRE reporting, these best practices may also be applicable to surveillance for other antimicrobial resistant organisms.

I. Communicating with Labs

A. State health agencies should clearly communicate with laboratories regarding reporting requirements for CRE. This communication should include:

- Whether CRE is reportable in their jurisdiction
- Their jurisdiction's surveillance definition for CRE. Note that this may differ from clinical definitions. The current CSTE position statement definition is as follows:
  - Carbapenem-Resistant *Enterobacteriaceae* (CRE): Any organism in the *Enterobacteriaceae* family that is resistant to at least one carbapenem antibiotic (i.e. doripenem, ertapenem, imipenem, meropenem).
  - Carbapenemase-Producing Carbapenem-Resistant *Enterobacteriaceae* (CP-CRE): Any organism in the *Enterobacteriaceae* family that tests positive for carbapenemase production (e.g. KPC, VIM, NDM, IMP, OXA-48-like) by a phenotypic (e.g. CarbaNP, mCIM, modified Hodge) OR tests positive for a known carbapenemase resistance mechanism by a recognized test (e.g. PCR, Xpert Carba-R).
- When to report CRE
- How to report: see HL7 ELR Implementation Guide
- Whom to contact at the public health jurisdiction for questions regarding testing methods and reporting

Examples of written guidance for labs (See Appendix C):

- Massachusetts
- New Mexico
- Indiana

B. State health agencies should also be aware of laboratory practices that may impact the quality of ELR messages for CRE. These may include:

- *Differences among laboratories in how CRE ELR messages are triggered*. If the lab is able to automate CRE ELR messaging, this will require less work for the lab and reduce

opportunities for missed reports. However, some labs will need to trigger ELRs manually, depending on a jurisdiction's definition of CRE and its complexity.

- *Laboratory compliance with current CLSI guidelines for MIC values.* The use of outdated MIC breakpoints can affect the interpretation of test results, especially for qualitative results.
- *Suppression of certain resistance test results according to CLSI guidelines and/or clinical formularies.* This may result in missing test results for some antimicrobials of interest to PHAs or inability to identify cases and report them to PHAs.

C. A survey of labs may be helpful to understand the test methods and breakpoints labs are using to identify CRE. Survey items may include:

- Laboratory's knowledge of CRE reportability and plans for reporting
- Capacity to identify organisms and perform susceptibility and carbapenemase testing
- Capacity to send test results via ELR, including version of HL7 ELR messages
- Tests used to identify organisms
- Tests and MIC interpretive criteria and or zone diameter interpretive criteria used to identify antimicrobial susceptibility
- Carbapenemase confirmatory tests
- Practices for sending isolates to other labs for additional testing
- The approximate number of *Enterobacteriaceae* results produced by the laboratory during a specific time period

II. Receiving and Processing HL7 ELR Messages

To fully assess antimicrobial resistance and categorize resistance properly, public health agencies need to receive enough information about resistance testing for specific organisms. This includes: 1) the antimicrobial/bactericidal agent being tested; 2) the method of testing (K-B, MIC, etc.); 3) the actual quantitative and qualitative results and interpretations. This information is used to monitor for multi-drug resistant organisms that require stronger antibiotics to treat infections.

Specific fields in the HL7 message allow for the CRE report (and other susceptibilities) to be reported to PHA. The message(s) used to report CRE (and other susceptibilities) should contain the organism, antibiotic susceptibilities, and the specimen source. The parent observation is the identified organism (e.g. *Klebsiella pneumoniae*) and the child observation is the antibiotic susceptibility results. The child observation should list all antibiotics tested against the organism, the measured MIC values, and the phenotypic interpretation (e.g. drug 1 … <1 ug/mL susceptible, drug 2 … = 2 ug/mL intermediate, drug 3 … >= 16 ug/mL resistant).

In order to link the parent-child observations together, the child OBR should contain a *sub_id*, sent in the child OBR 26.3, that links with the correct organism *sub_id* located in the parent OBX 4. The child OBR should also contain the *parent filler order number* and *placer order number* located in the OBR 29.2 and OBR 29.1 that matches the parent *filler order numbe and placer order number* located in the parent OBR 3.

http://www.hl7.org/implement/standards/product_brief.cfm?product_id=98

Simplified Example:

Message Type (HL7 2.5.1)
Example: **Multiple OBR segments**, has parent and child information MSH PID ORC OBR 1 OBX 1 OBX 2 SPM (such as a culture) OBR 2 (OBR-26 (Parent Result Link) and OBR-29 (Parent)) OBX 1 OBX 2 SPM (such as a bacterial isolate)
Counterexample: **Multiple OBR segments**, no parent and child information MSH PID ORC OBR 1 OBX 1 OBX 2 OBR 2 OBX 1 OBX 2

See Appendix D for additional examples of actual HL7 ELR messages for CRE. See Appendix E for additional guidance on parent-child relationships for culture and susceptibility testing.

Links to HL7 Implementation Guides:

HL7 2.5.1 for ELR is the ideal message structure for sending antimicrobial resistance messages, as it allows for the capturing of parent-child relationships in a more complete fashion than using HL7 2.3.1. Culture and susceptibility reporting is outlined in Appendix A of the R1 ELR IG.

HL7 Version 2.5.1 Implementation Guide: Electronic Laboratory Reporting to Public Health, Release 1 (US Realm) HL7 Version 2.5.1: ORU^R01:
http://www.hl7.org/implement/standards/product_brief.cfm?product_id=98
Section of Parent/child, Culture and Susceptibilities should be noted.

Errata for V251 Implementation Guide: Electronic Laboratory Reporting to Public Health (US Realm), Release 1
http://www.hl7.org/implement/standards/product_brief.cfm?product_id=245

*HL7 Version 2.5.1 Implementation Guide: S&I Framework Lab Results Interface, Release 1- US Realm**
http://www.hl7.org/implement/standards/product_brief.cfm?product_id=279

*A newer version of this implementation guide is currently in HL7 Ballot and is expected to be published later in 2017. This newer version will actually harmonize the Lab Ordering and Lab Results interfaces and will also include profiles to support more specific lab reporting use cases, including reporting to public health. This public health profile will in effect replace, or serve as an update to the previously referenced ELR implementation guide, list above. Once published, this document will be made available at http://www.hl7.org/implement/standards/product_matrix.cfm?ref=nav

A. Commonly observed deficiencies in received HL7 ELR messages:

1) *No utilization of parent/child linking of susceptibility labs to the organism(s), or parent/child relationships are used incorrectly.* Without proper parent/child linkages, determining which susceptibility results go with each identified organism may be difficult without the verification of paper laboratory results. See Appendix D on parent-child guidance.
    - *Recommendation*: Make sure facilities are submitting the correct linking values and the jurisdictions have the capabilities to utilize the parent/child result to link the susceptibility test to the organism.
2) *Missing organism.* Organism information is needed for public health to determine new versus recurrent cases.
    - *Example:* A reference lab may test for resistance mechanism but not for the organism, so a received report may only include the mechanism report and not be linked the original organism result.
    - *Recommendation:* Organism information should be sent.
3) *Missing specimen information: specimen source site (SPM8), specimen type, etc.* Specimen information is needed to determine the timeframe for defining a case as new or recurrent.
    - *Recommendation:* Specimen information should be sent.
4) *Results are sent in NTE segments.*
    - *Recommendation:* All results should be sent in an OBX segment; quantitative results should be sent in a numeric or structured numeric segment. Qualitative results should be sent in an OBX segment, perhaps using a CE or CWE data type, using national standard vocabulary such as LOINC and/or SNOMED. NTE segments should not be used to communicate important information.
5) *Comments are sent in multiple result (OBX) segments*. This can result in potentially important information not being communicated to downstream systems. If the

information does come through, use of multiple OBX segments can make reading results difficult.

- *Example:* OBX|7 "identification and susceptibility," OBX|8 "Testing to follow"
- *Recommendation*: Placing comments in NTE segments rather than OBX segments. When there are multiple OBXs, use the OBX|4 (observation sub-id) to group related OBXs

B. Issues with LOINC and SNOMED codes

1) *Generic LOINC codes may be used, making it difficult for system to classify results correctly*. Culture tests where LOINC codes are used are "generic" and require SNOMED codes in order to properly classify the results to the correct condition without being done manually. Positive culture results cannot be received by systems if generic LOINC codes are used without SNOMED codes.
   - *Recommendation:* utilize standard specific LOINC and SNOMED codes that can assist in properly identifying CRE, and work with laboratory and epidemiology staff to ensure that the selected codes are correct.
     - LOINC Code look up: https://search.loinc.org/
     - SNOMED Code look up: http://www.snomedbrowser.com/ https://uts.nlm.nih.gov//snomedctBrowser.html
2) *LOINC codes that do not specify the method used* (e.g. disk diffusion, broth dilution/MIC, ETest, etc.)
   - *Recommendation:* Labs should use method-specific LOINC codes.

C. Minimum Inhibitory Concentration (MIC) values.

Both MIC values and interpretations are needed by the PHA. MIC values are needed for trend data, which would be lost if only phenotypic interpretations are collected and the CLSI breakpoints used to determine those interpretations change over time.

1) Missing MIC values
   - *Recommendation:* Use the most current CLSI guidelines (M100-S27) for MIC breakpoints, available at http://clsi.org/m100/ (free web version).
2) Reference lab reporting of MIC values may be affected by their clients' limitations, such as their willingness and ability to receive MIC values. If ordering providers are not willing or able to receive MIC values, they may not be entered in the LIMS and reference labs may not be able to send these directly to PHAs.

D. Issues with sending laboratory's LIM system

1) *Missing carbapenemase results.* Lack of carbapenemase testing results (MHT/CarbaNP, molecular panels, PCR). Facilities may be performing carbapenemase testing but not sending results to PHAs. This results in PHAs not knowing the resistance mechanism for CRE cases and needing to contact facilities to find out the testing mechanism. Some labs may report these results in comments. Reports may say "carbapenemase production" without including what tests were used to come to that conclusion, or the lab may not have run the appropriate tests.

- *Recommendation:* PHAs should understand which labs in your jurisdiction are performing these tests. If a carbapenemase test is done, labs should send results, whether positive or negative.

2) *Ambiguous notes/comments which may or may not indicate that carbapenemase testing was performed.* Some labs perform carbapenemase testing while others make assumptions about carbapenemase production based on overall phenotype. ELR message comments may not always make it clear whether a test was performed or not.
   - *Examples:* "Demonstrates production of a carbapenemase," "Likely carbapenemase producer"
   - *Recommendation:* PHAs should request that labs include confirmatory carbapenemase test results as "child" linkages to the "parent" organism ID. If this isn't possible, PHAs should be aware of what carbapenemase test (if any) a lab uses, and what phenotypes trigger its use.

Appendices:

A. Glossary of terms:

Electronic Laboratory Reporting (ELR)
Public Health Agencies (PHA)
Carbapenem-Resistant Enterobacteriaceae (CRE)
Carbapenemase-Producing Carbapenem-Resistant *Enterobacteriaceae* (CP-CRE)
Minimum inhibitory concentrations (MIC)
Clinical and Laboratory Standards Institute (CLSI)
Health Level Seven (HL7)
Logical Observation Identifiers Names and Codes (LOINC)
Systematized Nomenclature of Medicine (SNOMED)

B. Additional resources:

- Laboratory Protocol for Detection of Carbapenem-Resistant or Carbapenemase-Producing, Klebsiella spp. and E. coli from Rectal Swabs: https://www.cdc.gov/HAI/pdfs/labSettings/Klebsiella_or_Ecoli.pdf
- CDC technical standards resources: https://www.cdc.gov/elr/technicalstandards.html

C. Sample written guidance for laboratories

- Massachusetts
- New Mexico
- Indiana

D. Examples of HL7 ELR messages for CRE

E. Parent/Child ELR Relationship for Culture and Susceptibility testing

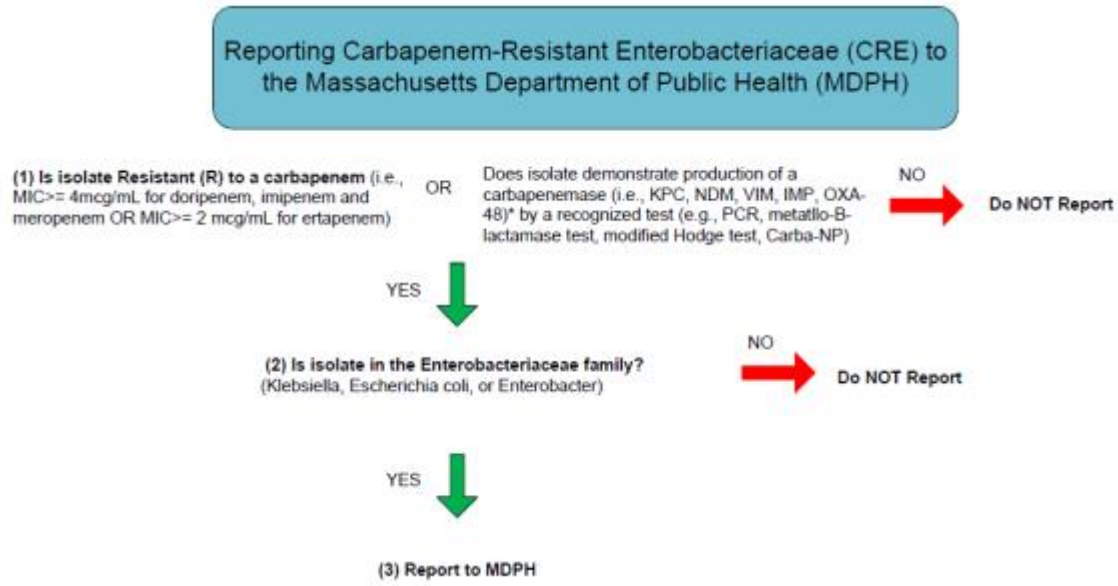
How to report Carbapenem-resistant Enterobacteriaceae to MDPH, September 2016

Introduction: Carbapenem-resistant Enterobacteriaceae (CRE) are an emerging and epidemiologically important threat. Carbapenem antibiotics are often used as the last line of treatment for infections caused by highly resistant bacteria, including those in the Enterobacteriaceae family. Increased antimicrobial resistance limits treatment options. Of increasing concern are carbapenemase-producing CRE (CP-CRE), which contain mobile resistance elements that facilitate transmission of resistance to other Enterobacteriaceae (1). Since first detection of CP-CRE in the United States in 1996 (2), CP-CRE have spread rapidly, with cases reported in 48 of 50 states (3). Infections with CP-CRE are difficult to treat and associated with high mortality rates (4). Early detection and aggressive implementation of infection prevention and control strategies are necessary to prevent further spread of CRE and CP-CRE. These strategies require an understanding of the prevalence or incidence of CRE and CP-CRE. The development and use of a standardized definition is central to this process.

The detection of and definitions for CRE are complicated. Unlike other antibiotic-resistant organisms like methicillin-resistant *Staphylococcus aureus*, which represent a single species and a single resistance mechanism, Enterobacteriaceae are a family of more than 70 organisms, and carbapenem resistance can be due to a variety of mechanisms (5). Carbapenemase production, most commonly *Klebsiella pneumoniae* carbapenemase (KPC), has been primarily responsible for the emergence of CRE in the United States over the last decade (5). For this reason, CP-CRE have become an important target for prevention. However, there is wide variability in the capacity of clinical and public health laboratories to test for carbapenemase production as the mechanism for carbapenem resistance. CRE definitions that include all isolates testing as nonsusceptible to at least one carbapenem are sensitive but might lack specificity for the most common CP-CRE currently found in the United States (KPC). Due to this limitation, certain phenotypic definitions have been developed to identify likely CP-CRE to define priorities for aggressive prevention interventions. Regardless of the definition, any organism nonsusceptible to a carbapenem may be considered a multidrug-resistant organism and warrant the use of transmission-based precautions for patients admitted to a healthcare facility (e.g., Contact Precautions).

In 2014, CDC conducted an evaluation of the 2012 CRE definition (used by the Emerging Infections Program (5) and in the 2012 CDC CRE toolkit (6)) using 312 *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp. isolates nonsusceptible to at least one carbapenem (7). Results from these analyses demonstrated that the 2012 CDC definition misclassified 13% of carbapenem nonsusceptible *Klebsiella* spp. and 21% of KPC-producing *Klebsiella* spp. as non-CP. A CRE definition (the 2015 definition proposed here) that included isolates resistant to any carbapenem (including ertapenem) rarely missed CP strains, but captured a higher proportion of non-CP strains (55%). Adding the modified Hodge test (MHT) to this definition decreased the non-CP-CRE captured from 55% to 12%.

Case definition: *Enterobacter* spp., *E.coli* or *Klebsiella* spp., from any clinical specimen resistant to any carbapenem (minimum inhibitory concentrations of ≥4 mcg/ml for meropenem, imipenem, and doripenem or ≥ 2 mcg/ml for ertapenem) OR production of a carbapenemase (e.g., *Klebsiella pneumoniae* carbapenemase [KPC], New Delhi metallo-β-lactamase [NDM], Verona integron-encoded metallo-β-lactamase [VIM], imipenemase [IMP] metallo-β-lactamase, OXA-48 carbapenemase) demonstrated by a recognized test (e.g., polymerase chain reaction, metallo-β-lactamase test, modified Hodge test, Carba NP). Include all susceptibility results (quantitative MIC value, and qualitative interpretation (S, I, R),), plus all results regarding carbapenemase production (positive or negative).



Using the ELR portal

Go to the Organism tab and look for Multi Drug Resistant Organism in the drop-down list

Here's the description of what to report:

Clinical Description: Carbapenem-resistant Enterobacteriaceae (CRE) infections have many different clinical presentations. Colonization with a CRE is sometimes detected through surveillance cultures.

What to Report:
- Isolation of *Escherichia coli*, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Enterobacter aerogenes*, or *Enterobacter cloacae* with resistance to imipenem, meropenem, doripenem, or ertapenem (from any site);
- Any isolate of *Escherichia coli*, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Enterobacter aerogenes*, or *Enterobacter cloacae* that demonstrates production of a carbapenemase (e.g., KPC, NDM, VIM, IMP, OXA-48) by a recognized test (e.g., polymerase chain reaction, metallo-ß- lactamase test, modified Hodge test, Carba NP).
- Include susceptibility result values (MIC) and interpretations (S, I, R).

Here are the available test/result codes:

LOINC	LOINC NAME	SNOMED	SNOMED NAME
11475-1	Microorganism identified : PrId : Pt : xxx : Nom : Culture	112283007	Escherichia coli
		14385002	Enterobacter cloacae
		62592009	Enterobacter aerogenes
		56415008	Klebsiella pneumonia
		40886007	Klebsiella oxytoca

75683-3	bla(KPC) Ql Prb Mag	10828004 260385009	Positive Negative
75686-6	bla(IMP) Ql Prb Mag	10828004 260385009	Positive Negative
75684-1	bla(NDM) Ql Prb Mag	10828004 260385009	Positive Negative
75685-8	bla(VIM) Ql Prb Mag	10828004 260385009	Positive Negative
75687-4	bla(OXA) Ql Prb Mag	10828004 260385009	Positive Negative

Once you have completed your mapping, please test your mapping in the Staging site first. Send one or two test messages through and let us know; we will review them and give you the go-ahead to send them into the LIVE ELR portal.

References

1. Gupta N, et al. Carbapenem-Resistant Enterobacteriaceae. Clin Infect Dis 2011; 53:60-67

2. Yigit H, et al. Novel Carbapenem-Hydrolyzing Beta-Lactamase, KPC-1, from a Carbapenem-Resistant Strain of *Klebsiella pneumoniae*. Antimicrob Agent Chemother 2001; 45:1151-1161

3. CDC. Carbapenemase-Producing Carbapenem-Resistant Enterobacteriaceae in the United States. Available at http://www.cdc.gov/hai/organisms/cre/TrackingCRE.html . Last viewed 5 March 2015

4. Patel G, et al. Outcomes of Carbapenem-Resistant *Klebsiella pneumoniae* Infection and the Impact of Antimicrobial and Adjunctive Therapies. Infect Control Hosp Epidemiol 2008; 29:1099-1106

5. CDC. Vital Signs: Carbapenem-Resistant *Enterobacteriaceae*. MMWR Morb Moral Wkly Rep. 2013;62:165-170

6. Centers for Disease Control and Prevention (CDC): Guidance for control of Carbapenem Resistant Enterobacteriaceae (CRE): 2012 CRE toolkit available at: http://www.cdc.gov/hai/organisms/cre/cre-toolkit/index.html

7. Chea N, Bulens SN, Kongphet-Tran T et al An evaluation of phenotypic definitions for the identification of carbapenemase-producing carbapenem-resistant Enterobacteriaeceae, United States. Emerging Infectious Diseases (in press)

Reporting Carbapenem-resistant Enterobacteriaceae (CRE) to the New Mexico Department of Health via ELR

Interim guidance
January 2017

CRE Reporting guidelines

Reporting guidelines are designed to capture all cases that fit the NM-DOH CRE and CP-CRE case definition, to identify organisms with resistance and to allow NM-DOH to differentiate between CRE cases and CP-CRE cases.

When to Report:	Laboratory isolation of **any Enterobacteriaceae genera with resistance** to imipenem, meropenem, doripenem, or ertapenem *from any site*.
	Whenever an Enterobacteriaceae genera organism is tested for **resistance mechanism**.
	Any **diagnosis of Carbapenem-resistant Enterobacteriaceae (CRE)** or Carbapenamase-producing CRE (CP-CRE) infection or colonization.
What to Report:	The **Enterobacteriaceae genera** that is resistant to carbapeneamase.
	The results of all susceptibility testing done on the specimen, including MIC and interpretations
	All results (positive and negative) resistance mechanism tests (Modified Hodge Test, CarbaNP, KPC, NDM, VIM, IMP, OXA-48, etc).
Reporting regulations	https://nmhealth.org/publication/view/regulation/372/ http://164.64.110.239/nmac/parts/title07/07.004.0003.htm

For additional guidance or if any of these components cannot be reported via ELR, please contact Amy Drake (amy.drake@state.nm.us or 505-827-0046).

Carbapenemase Producting – Carbapenem Resistant *Enterobacteriaceae*

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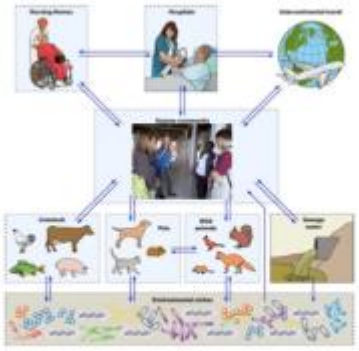
Our Goals for Today:

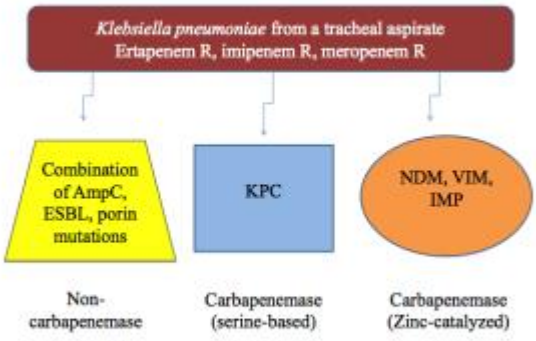
1. Understand the differences between CRE and CP-CRE and how this impacts transmission
2. Understand how to screen for CP-CRE and submit isolates to ISDH for confirmation
3. Learn some new (or old) lab methods
4. Ask Lots of Questions!
5. Make some new contacts!

NATIONAL ACTION PLAN FOR COMBATING ANTIBIOTIC-RESISTANT BACTERIA

Epidemiology and Laboratory Capacity Cooperative Agreement

Antibiotic Resistance Threats in the United States, 2013





What about all of these acronyms?

Organism Group	Glucose Non-Fermenters		Enterobacteriaceae	
Resistance Mechanism	Inherent	Carbapenemase	ESBL or AmpC plus porin loss	Carbapenemase
CRE	-	-	Y	Y
CP-CRE	-	-	-	Y

CRE – Carbapenem Resistant *Enterobacteriaceae*
CP-CRE – Carbapenemase Producing-Carbapenem Resistant *Enterobacteriaceae*

In Indiana, CP-CRE is reportable for both isolates and condition.

- **CDR Modification Highlights Actionable Interventions**
- **Sets a timeline (72 hours) for investigation**
- **Puts a focus on acute care and long term care**
- **Prevent spread by encouraging:**
  - **Contact precautions**
  - **CDC CRE Toolkit Use**
  - **Screening for colonizatio**
  - **Chlorhexidine bathing**

Based on the potential for transmissibility, the Communicable Disease rule focuses on CP-CRE.

In order to narrow the amount of isolates required to submit to the state, the following isolate submission criteria were adopted:

The new CDR requires laboratories to submit organisms that are

nonsusceptible to at least one (1) carbapenem antibiotic

AND

are phenotypic positive for carbapenemase production (ex. Modified Hodge, CarbaNP, etc.)

or

are nonsusceptible to at least three (3) carbapenem antibiotics

or

are positive for a carbapenemase gene marker

Isolates include organisms that are non-susceptible to at least one carbapenem antibiotic with MIC >=2 µg/ml or zone diameter <=22 mm (<=21 mm for ertapenem)

AND one of the following criteria:

1. Are positive for carbapenemase production by a phenotypic test (e.g. Modified Hodge, or Carba NP).
2. Are non-susceptible to at least three carbapenem antibiotics with MIC >=2 µg/ml or zone diameter <=22 mm (<=21 mm for ertapenem).
3. Are positive for a carbapenemase gene marker.

Only one isolate that meets these criteria should be submitted if the same organism is repeatedly recovered from the same patient.

Why these criteria?

How were they selected?

How does that impact my lab?

Some history…..

In 2013 Indiana began receiving and testing CRE isolates based on the CDC's recommendation that were resistant to

all 3rd-generation cephalosporins

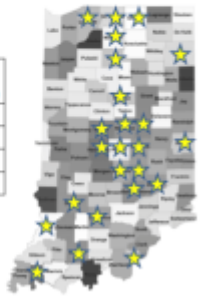
& at least

one carbapenem antibiotic

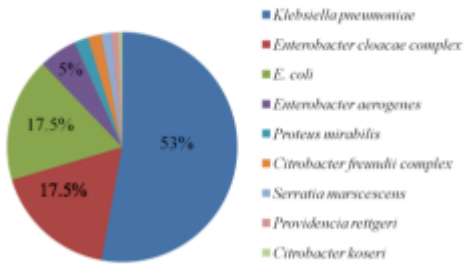
Indiana CRE Pilot: 2013-2015

Year	Submitters (n)	Isolates Submitted (n)
2013	24	167
2014	19	201
2015*	18	191
Total	32	559

*Through August 2015



Broad Distribution of Pilot Organisms

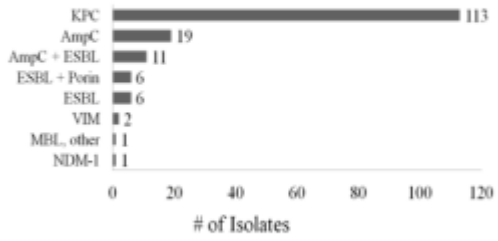


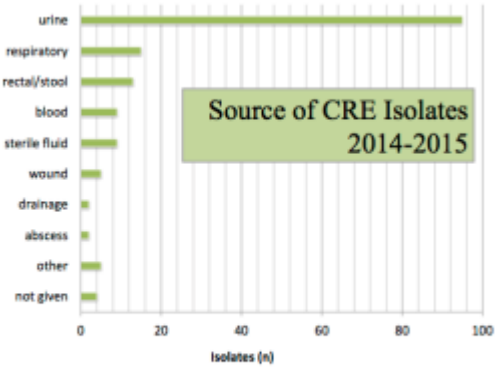
August 2014 – July 2015

ISDH performed CRE testing on 206 isolates submitted from 21 laboratories across the state.

- Each laboratory submitted on average 9-10 isolates [range 1-57]
- 77.2% met the CDC CRE-definition
- Testing Performed: 12-disc AST, MBL Etest, Modified Hodge, CarbaNP, KPC/NDM-1 PCR

Resistance Mechanisms of Submitted Isolates 2014-2015





Approximately 23% of CRE isolates submitted during this time period did not meet the CDC Definition.

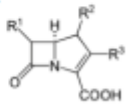
Sources of this potential discrepancy included:

1) Differences in AST interpretation
2) Number of 3rd generation cephalosporins routinely tested by the submitting laboratory
3) Center-specific differences in interpretation

AST-based Review and Reporting: A Data-Driven Decision

Review of unnecessary submissions from 2013-2015:

- 98.8% of these submissions could have been prevented with the CDR algorithm:
  - 55.6% by specifying the MIC or Zone Diameter
  - 43.2% by assessing phenotypic carbapenemase production
- Only 58% of these submissions would have been prevented with an alternative submission criteria of resistance to only 2 carbapenems



Structure of carbapenem backbone, wikipedia.org

Challenges for Laboratories: AST-based Review and Reporting

- CLSI-independent criteria: MIC or zone diameter
- Resistance to 3 carbapenems removes requirement for phenotypic carbapenemase assessment
- Projected use of molecular markers as a means for screening in the future (ex. PCR, CarbaR)

Three day submission criteria …

(1) CP-CRE
(2) Haemophilus influenzae, invasive disease.
(3) Neisseria meningitidis, invasive disease.
(4) STEC
(5) VRSA
(6) Mycobacterium tuberculosis.
(7) S. pneumoniae invasive disease (<5yo)
(8) Listeria monocytogenes (sterile sites)
(9) Salmonella sp. (clinical specimen)
(10) Shigella sp. (clinical specimen)
(11) Vibrio cholerae (stool or vomit)
(12) Vibrio sp. (clinical specimen)

ISDH Algorithm

Day 1 – Receive isolate and subculture

Day 2* – Confirm ID and Perform PCR
- MALDI-TOF MS
- Multiplex PCR [KPC, NDM-1, OXA-48, IMP, VIM]

If Positive, report Finalized result.
- Ex. *Klebsiella pneumoniae*, KPC positive

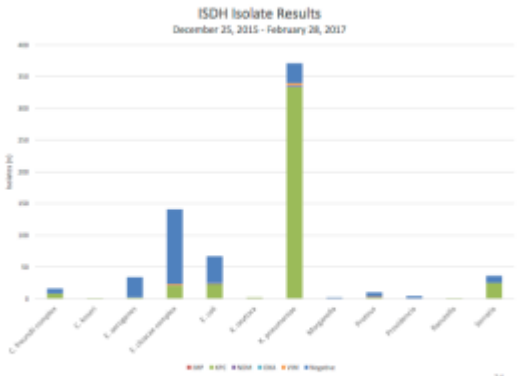
If Negative – report Preliminary Negative.

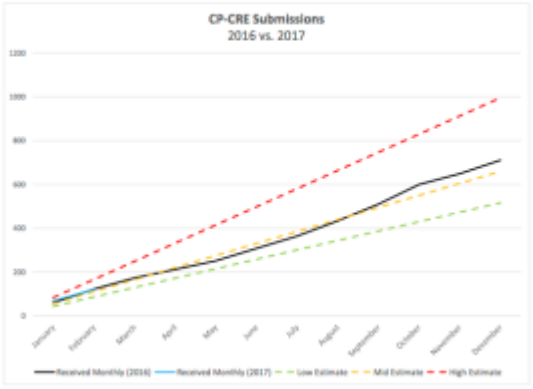
Day 3 – CarbaNP on PCR negative specimens

If Positive, send to CDC for further testing.
If Negative, report out as Negative.

CDR went into effect December 25, 2015

What does CP-CRE look like now?





CP-CRE Submissions by County

December 25, 2015 through October 15, 2016

Thanks to …

Jon Radosevic, Kelly Tippmann
Cassie Campion, Kiran Khurana, Nick Hinkley, Elizabeth Wells

ISDH Epi
Tina Feaster
Nicole Hearon
DJ Shannon

ISDH LIMS
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ISDH Labs
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Lixia Liu*
Mark Glazier
Kate Wainwright

ISDH Outreach/Training
Shelley Matheson
Jyl Madlem

Our Goals for Today:

1. Understand the differences between CRE and CP-CRE and how this impacts transmission
2. Understand how to screen for CP-CRE and submit isolates to ISDH for confirmation
3. Learn some new (or old) lab methods
4. Ask Lots of Questions!
5. Make some new contacts!

NEXT UP: Break
THEN: Overview of CarbaNP Test

Sample HL7 2.5.1 ELR for CRE

```
FHS|^~\&|LABCORP-CORP|LABCORP-34D0655059-CLIA|LABCORP-34D0655059-CLIA|MA|201612020130||FHSeg|No Comment|FHSAppGen20161202033|Application Generate
BHS|^~\&|LABCORP-CORP|LABCORP-34D0655059-C|MADOH|MA|201612020130||BHSeg|Application Generated|BHSAppGen20161202033|P
MSH|^~\&|LABCORP-CORP|LABCORP-34D0655059-CLIA|MADOH|MA|201612020130||ORU^R01|20161202033821654B7|P|2.3.1|||||||
PID|1|7966254|33363191500^^^^PI^LabCorp Raritan&31D0125232&CLIA||BOOP^BETTY||19650531|F||C|32 EAST SPRINGFIELD STREET^^BOSTON^MA^02118||^^^^^617^6516598|||||||U|||||||
NK1|1|||||||||||||||||||||||||||||||||||
ORC|||||||||||||||||||||||Partners BOS Newton|71 Needham St^^NEWTON^MA^02458|^^^^^857^5984460|71 Needham St^^NEWTON^MA^02458
OBR|1||333631919899|630-4^Bacteria identified^LN^008847^Urine Culture, Routine^L|||20161212131900||||||201612122956|URINE^^URINE|1508835653^BARRY^PHILIP^^^^^MD^^^^^^NPI|^^^^^977^1234567|||||||F|||||||||||||||||||
OBX|1|CE|630-4^Bacteria identified^LN^997131^RSLT#1^L|1|446870005^Carbapenem resistant Klebsiella pneumoniae^SCT^CREKP^Carbapenem-resistant Enterobacteriaceae (CRE) - Klebsiella pneumoniae^L|||A|||F|||
        20161201112051|31D0125232^LabCorp Raritan^CLIA||
NTE|1|L|Carbapenem-resistant Enterobacteriaceae (CRE) - Klebsiella pneumoniae|
NTE|2|L|Greater than 100,000 colony forming units per mL|
OBR|2||33363191999|630-4^Bacteria identified^LN^997131^Result 1^L|||20161212713190||||||201612122251|URINE^^URINE|1508835653^BARRY^PHILIP^^^^^MD^^^^^^NPI|^^^^^999^1234567|||||||||
      F|630-4&Bacteria identified&LN&997131&RSLT#1&L^1^CREKP|||^33363191500|||||||||||||||||
OBX|1|CE|20-8^Amoxicillin+Clavulanate^LN^998001^Amoxicillin/Clavulanic Acid^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|2|CE|28-1^Ampicillin^LN^998002^Ampicillin^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|3|CE|76-0^Cefazolin^LN^998007^Cefazolin^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|4|CE|6644-9^Cefepime^LN^998049^Cefepime^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|5|CE|141-2^Ceftriaxone^LN^998012^Ceftriaxone^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|6|CE|145-3^Cefuroxime.parenteral^LN^998014^Cefuroxime^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|7|CE|161-0^Cephalothin^LN^998015^Cephalothin^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|8|CE|185-9^Ciprofloxacin^LN^998017^Ciprofloxacin^L|1|813185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|9|CE|267-5^Gentamicin^LN^998020^Gentamicin^L|1|813185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|10|CE|279-0^Imipenem^LN^998023^Imipenem^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|11|CE|20396-8^Levofloxacin^LN^998044^Levofloxacin^L|1|813185005^Sensitive^SCT^S^Sensitive^L||p|S|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|12|CE|363-2^Nitrofurantoin^LN^998026^Nitrofurantoin^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|13|CE|408-5^Piperacillin^LN^998031^Piperacillin^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|14|CE|496-0^Tetracycline^LN^998033^Tetracycline^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|15|CE|508-2^Tobramycin^LN^998036^Tobramycin^L|1|813185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|16|CE|516-5^Trimethoprim+Sulfamethoxazole^LN^998037^Trimethoprim/Sulfa^L|1|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201112051|31D0125232^LabCorp Raritan^CLIA||^MIC
MSH|^~\&|LABCORP-CORP|LABCORP^34D0655059^CLIA|MADOH|MA|201612020130||ORU^R01|20161202033116978184|P|2.3.1|||||||
PID|1|044739|32770890190^^^^PI^LabCorp Raritan&31D0125232&CLIA||BRACERO^DOMINGA||19471101|F||U|||||||||||U|||||||
NK1|1|||||||||||||||||||||||||||||||||||
ORC|||||||||||||||||||||||Whittier Rehab West Micro|145 Ward Hill Ave^^BRADFORD^MA^01835|^^^^^978^3728000|145 Ward Hill Ave^^BRADFORD^MA^01835
OBR|1||32770890190|634-6^Bacteria identified^LN^008649^Aerobic Bacterial Culture^L|||20161122050||||||201611222216|WOUND^^WOUND||^^^^^978^3728000|||||||P|||||||||||||||||||
OBX|1|CE|6463-4^Bacteria identified^LN^997880^RSLT#3^L|3|40886007^Klebsiella oxytoca^SCT^KLEBOX^Klebsiella oxytoca^L|||A|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||
NTE|1|L|Klebsiella oxytoca|
NTE|2|L|Moderate growth|
NTE|3|L|Carbapenem-resistant Enterobacteriaceae (CRE)|
OBR|2||32770890190|6463-4^Bacteria identified^LN^997880^Result 3^L|||20161122050||||||201611222216|WOUND^^WOUND||^^^^^978^3728000|||||||P|6463-4&Bacteria identified&LN&997880&RSLT#3&L^3^KLEBOX||
      |^32770890190|||||||||||||||||
OBX|1|CE|12-5^Amikacin^LN^998000^Amikacin^L|3|264841006^Intermediately susceptible^SCT^I^Intermediately susceptible^L|||I|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|2|CE|20-8^Amoxicillin+Clavulanate^LN^998001^Amoxicillin/Clavulanic Acid^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|3|CE|28-1^Ampicillin^LN^998002^Ampicillin^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|4|CE|32-3^Ampicillin+Sulbactam^LN^998003^Ampicillin/Sulbactam^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|5|CE|76-0^Cefazolin^LN^998007^Cefazolin^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|6|CE|6644-9^Cefepime^LN^998049^Cefepime^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|7|CE|108-1^Cefotaxime^LN^998009^Cefotaxime^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|8|CE|133-9^Ceftazidime^LN^998010^Ceftazidime^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|9|CE|141-2^Ceftriaxone^LN^998012^Ceftriaxone^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|10|CE|145-3^Cefuroxime.parenteral^LN^998014^Cefuroxime^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|11|CE|185-9^Ciprofloxacin^LN^998017^Ciprofloxacin^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|12|CE|267-5^Gentamicin^LN^998020^Gentamicin^L|3|813185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|13|CE|279-0^Imipenem^LN^998023^Imipenem^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|14|CE|20396-8^Levofloxacin^LN^998044^Levofloxacin^L|3|264841006^Intermediately susceptible^SCT^I^Intermediately susceptible^L|||I|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|15|CE|6652-2^Meropenem^LN^998045^Meropenem^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|16|CE|408-5^Piperacillin^LN^998031^Piperacillin^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|17|CE|496-0^Tetracycline^LN^998033^Tetracycline^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|18|CE|508-2^Tobramycin^LN^998036^Tobramycin^L|3|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
OBX|19|CE|516-5^Trimethoprim+Sulfamethoxazole^LN^998037^Trimethoprim/Sulfa^L|3|813185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20161201094245|31D0125232^LabCorp Raritan^CLIA||^MIC
BTS|68|'Application Generated'|
FTS|1|'Application Generated'
```

Sample HL7 2.3.1 ELR for CRE

```
FHS|^~\&|MEDITECH|BHS|ELR|MDPH|20161211||2016121122D0068014|||
BHS|^~\&|MEDITECH|BHS|ELR|MDPH|20161211||2016121122D0068014|||
MSH|^~\&|SENDER_CDR-ENSEMBLE^MIC^|BWH^22D0666524^CLIA|ELR|MDPH|201702230907||ORU^R01|201702230858BWH|P|2.3.1
PID|1||97198121^^^^BWH||LastName^FirstName^||19870105|F||^^CDCREC^^^L|00 4TH AVE^^BOSTON^MA^02111^UNITED STATES||^^^^^^|||||||||^^^^^L||||||||N
NK1|1|^^||^^^^^
ORC|RE|||||||||||||||||||Brigham and Women's Hospital^L^^^^^^^^22D0666524|75 Francis Street^^Boston^MA^02115^USA|^^^^^617^7325000^7383|75 Francis Street^Suite A^Boston^MA^02115^USA
OBR|1|AAH20004025_20170223071800^BWH^L|169321^CDR^L|UC^URINE CULTURE^L^630-4^^LN|||201702230600|||||||201702230717|&&& Urine|1043260573^ProviderLastName^ProviderMiddleName^ProviderFirstName^MD^
     ^^^^^617^7326040|||||201702230723|||F||||UC^URINE CULTURE^L^630-4^^LN
NTE|1|RE|TEST FOR CDR|
NTE|1|L|URINE|RE
OBX|1|CE|^^^11475-1^Microorganism identified : PrId : Pt : xxx : Nom : Culture^LN|1|^^^409800005^ESCHERICHIA COLI ESBL^SCT||||||F|||201702230723|22D0666524
NTE|1|L|>100,000 colony forming units per ml|RE
OBR|2|AAH20004025_20170223071800^BWH^L|169321^CDR^L|VITEK MIC^VITEK MIC^L^50545-3^BACTERIA SUSCEPTIBILITY^LN|||201702230600|||||||&&& Urine|||||||
     201702230723|||F|&&&11475-1&&L^^409800005|||AAH20004025_20170223071800&BWH^1693214CDR|||||||||||||||||||||UC^URINE CULTURE^L^630-4^Bacteria identified in Urine by Culture^LN
OBX|1|SN|AMK^amikacin^L^18860-7^Amikacin Susc^LN|1|^0.1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|2|SN|AUG^amoxicillin/clavulanate^L^18862-3^Amoxicillin+Clav Susc^LN|1|^0.5|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|3|SN|AMP^ampicillin^L^18864-9^Ampicillin Susc^LN|1|^16|MM^Millimeter^UCUM|Not Available|I|||F|||201702230723|22D0666524
OBX|4|SN|CZLU^cefazolin (urine)^L^16566-2^Cefazolin (urine)^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|5|SN|FEP^cefepime^L^18879-7^Cefepime Susc^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|6|SN|FOX^cefoxitin^L^18888-8^Cefoxitin Susc^LN|1|^16|MM^Millimeter^UCUM|Not Available|I|||F|||201702230723|22D0666524
OBX|7|SN|CTZ^ceftazidime^L^18893-8^Ceftazidime Susc^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|8|SN|CRO^ceftriaxone^L^18895-3^Ceftriaxone Susc^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|9|SN|CIP^ciprofloxacin^L^18906-8^Ciprofloxacin Susc^LN|1|^0.5|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|10|SN|ERT^ertapenem^L^35802-8^Ertapenem Susc^LN|1|^8|MM^Millimeter^UCUM|Not Available|R|||F|||201702230723|22D0666524
OBX|11|SN|GEN^gentamicin^L^18928-2^Gentamicin Susc^LN|1|^0.5|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|12|SN|LVX^levofloxacin^L^20629-2^L-Floxacin Susc^LN|1|^0.5|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|13|SN|FUR^nitrofurantoin^L^18955-5^Nitrofurantoin Susc^LN|1|^64|MM^Millimeter^UCUM|Not Available|I|||F|||201702230723|22D0666524
OBX|14|SN|TZP^piperacillin/tazobactam^L^18970-4^Piperacillin+Tazobac^LN|1|^0.5|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|15|SN|TET^tetracycline^L^18993-6^Tetracycline Susc^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|16|SN|TOB^tobramycin^L^18996-9^Tobramycin Susc^LN|1|<=^1|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524
OBX|17|SN|TRI^trimethoprim/sulfamethoxazole^L^18998-5^TMP SMX Susc^LN|1|^20|MM^Millimeter^UCUM|Not Available|S|||F|||201702230723|22D0666524

BTS|1
FTS|1
```

Sample HL7 2.3.1 ELR for CRE

```
MSH|^~\&|LABCORP-CORP|LABCORP^34D0655059^CLIA|CADOH|CA|201704210130|CA001|ORU^R01|20170421014808371912|P|2.3.1|||||||
PID|1|NI|99999999999^^^^PI^LabCorp Phoenix&03D0528350&CLIA||lastname^firstname||19350826|F||U|number and street^^town^NM^99999||^^^^^999^9999999|||||||||U||||||||
ORC|||||||||||||||||||||Mariner HCP HomeCare Physician|3565 Del Amo Blvd^^TORRANCE^CA^90503|^^^^^310^2145723|3565 Del Amo Blvd^^TORRANCE^CA^90503
OBR|1||10749460490|630-4^Bacteria identified^LN^008847^Urine Culture, Routine^L|||201704171200|||||||201704171553|UC^^UC|1659681096^CRAIG^GLORIA^PEREZ^^^NP^^^^^^NPI|^^^^^310^2145723|||||||
F|||||||||||||||||||
OBX|1|CE|630-4^Bacteria identified^LN^997132^RSLT#2^L|2|14385002^Enterobacter cloacae^SCT^ENTECL^Enterobacter cloacae^L|||A|||F|||20170420185152|05D0571200^LabCorp San Diego^CLIA||^
NTE|1|L|Enterobacter cloacae|
NTE|2|L|Greater than 100,000 colony forming units per mL|
NTE|3|L|Carbapenem-resistant Enterobacteriaceae (CRE)|
NTE|4|L|Ertapenem Nonsusceptible|
OBR|2||10749460490|630-4^Bacteria identified^LN^997132^Result 2^L|||201704171200|||||||201704171553|UC^^UC|1659681096^CRAIG^GLORIA^PEREZ^^^NP^^^^^^NPI|^^^^^310^2145723|||||||F|630-4&Bacteria
identified&LN&997132&RSLT#2&L^2^14385002&Enterobacter cloacae&SCT&ENTECL&Enterobacter cloacae&L|||^10749460490|||||||||||||||
OBX|1|CE|20-8^Amoxicillin+Clavulanate^LN^998001^Amoxicillin/Clavulanic Acid^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|2|CE|28-1^Ampicillin^LN^998002^Ampicillin^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|3|CE|76-0^Cefazolin^LN^998007^Cefazolin^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|4|CE|6644-9^Cefepime^LN^998049^Cefepime^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|5|CE|141-2^Ceftriaxone^LN^998012^Ceftriaxone^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|6|CE|145-3^Cefuroxime,parenteral^LN^998014^Cefuroxime^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|7|CE|185-9^Ciprofloxacin^LN^998017^Ciprofloxacin^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|8|CE|35801-0^Ertapenem^LN^998183^Ertapenem^L|2|30714006^Resistant^SCT^R^Resistant^L|||R|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|9|CE|267-5^Gentamicin^LN^998020^Gentamicin^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|10|CE|279-0^Imipenem^LN^998023^Imipenem^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|11|CE|20396-8^Levofloxacin^LN^998044^Levofloxacin^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|12|CE|363-2^Nitrofurantoin^LN^998026^Nitrofurantoin^L|2|264841006^Intermediately susceptible^SCT^I^Intermediately susceptible^L|||I|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|13|CE|496-0^Tetracycline^LN^998033^Tetracycline^L|2|264841006^Intermediately susceptible^SCT^I^Intermediately susceptible^L|||I|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|14|CE|508-2^Tobramycin^LN^998036^Tobramycin^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
OBX|15|CE|516-5^Trimethoprim+Sulfamethoxazole^LN^998037^Trimethoprim/Sulfa^L|2|83185005^Sensitive^SCT^S^Sensitive^L|||S|||F|||20170420183736|05D0571200^LabCorp San Diego^CLIA||^MIC
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Parent/Child ELR Relationship for Culture and Susceptibility testing

Background: The use of a parent/child relationships is to link together child sensitivity results to the parent culture results. This is important in public health surveillance to determine the resistance of organisms to different types of medications. These results are used to monitor for super-bugs that require stronger antibiotics to treat simple infections.

In HL7 2.5.1 structure, this can be done in the observation request (OBR) segment of the HL7 message by linking the parent filler order number located in OBR 3 to the child Parent sequence located in OBR 29.2 (See example below with segments highlighted).

MSH|^~\&|NIST^2.16.840.1.113883.3.72.5.20^ISO|NIST^2.16.840.1.113883.3.72.5.21^ISO|NIST^2.16.840.1.113883.3.72.5.22^ISO|NIST^2.16.840.1.113883.3.72.5.23^ISO|20120821140551-0500||ORU^R01^ORU_R01|NIST-ELR-004.01|T|2.5.1|||NE|NE|||||PHLabReport-NoAck^HL7^2.16.840.1.113883.9.11^ISO
SFT|NIST Lab, Inc.^L^^^^NIST&2.16.840.1.113883.3.987.1&ISO^XX^^^123544|3.6.23|A-1 Lab System|6742873-12||20100617
PID|1||PATID1234^^^&2.16.840.1.113883.3.72.5.24&ISO^MR^Seminole Cnty Hlth C&2.16.840.1.113883.3.0&ISO||Jones^William^A^^^^L||19610615|M||2106-3^White^CDCREC|1955 Seminole Lane^^Oveido^FL^32765^USA^H^^12059||^PRN^PH^^1^407^2351234|||||||||N^Not Hispanic or Latino^HL70189^NL^not latino^L^2.5.1
ORC|RE|ORD723222-4^^2.16.840.1.113883.3.72.5.24^ISO|R-783274-4^LIS^2.16.840.1.113883.3.72.5.25^ISO|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI||^PRN^PH^^^407^2341212||||||Seminole County Health Clinic|555 Orange Ave^^Oviedo^FL^32765^^B|^WPN^PH^^^813^8847284|555 Orange Ave^^Oviedo^FL^32765^^B
OBR|1|ORD723222-4^^2.16.840.1.113883.3.72.5.24^ISO|R-783274-4^LIS^2.16.840.1.113883.3.72.5.25^ISO|625-4^Bacteria identified in Stool by Culture^LN^3456543^CULTURE
STOOL^99USI^2.40|||20110528|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI|^PRN^PH^^^407^2341212|||||201106010900-0500|||F
OBX|1|CWE|625-4^Bacteria identified in Stool by Culture^LN^Bacteria identified^Bacteria identified^99USI^2.40|1|85729005^Shigella flexneri^SCT^^^^^^Shigella flexneri|||||F|||20110528|||||20110531130655-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
SPM|1|^ORD723222-4&&2.16.840.1.113883.3.72.5.24&ISO||119339001^Stool specimen^SCT^^^^07/31/2012||||||||||||20110528|20110529
OBR|2||R-783274-5^LIS^2.16.840.1.113883.3.72.5.25^ISO|50545-3^Bacterial susceptibility panel in Isolate by Minimum inhibitory concentration (MIC)^LN^Bact suscept^Bacteria susceptibility^99USI^2.40|||20110528|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI|^PRN^PH^^^407^2341212|||||201106010900-0500|||F|625-4&Bacteria identified in Stool by Culture&LN&Bacteria identified&Bacteria identified&99USI^^Shigella flexneri|||^R-783274-4&LIS&2.16.840.1.113883.3.72.5.25&ISO
OBX|1|SN|20-8^Amoxicillin+Clavulanate [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^AmoxClav^Amoxicillin-clavulanic acid^99USI^2.40||=^16|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||I^Intermediate^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|2|SN|516-5^Trimethoprim+Sulfamethoxazole [Susceptibility] by Minimum inhibitory concentration

(MIC)^LN^TMP-SMX^Trimethoprim-sulfamethoxazole^99USI^2.40||=^8^/^152|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||R^Resistant^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|3|SN|185-9^Ciprofloxacin [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^CIPROFLOXACIN^CIPROFLOXACIN^99USI^2.40||<=^0.06|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||S^Susceptible^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI

When a culture grows more than one organisms, the message sent may contain multiple susceptibility (child) results, one susceptibility result group for each organism. To make sure the child results successfully link to the correct parent results, the child OBR segment should contain a sub_id, sent in the Parent Result sequence located in OBR 26.2, that links with the correct organism sub_id located in the parent result's OBX 4 segment, sub_id (see example below with segments highlighted in green).

MSH|^~\&|NIST^2.16.840.1.113883.3.72.5.20^ISO|NIST^2.16.840.1.113883.3.72.5.21^ISO|NIST^2.16.840.1.113883.3.72.5.22^ISO|NIST^2.16.840.1.113883.3.72.5.23^ISO|20120821140551-0500||ORU^R01^ORU_R01|NIST-ELR-004.01|T|2.5.1|||NE|NE|||||PHLabReport-NoAck^HL7^2.16.840.1.113883.9.11^ISO
SFT|NIST Lab, Inc.^L^^^^NIST&2.16.840.1.113883.3.987.1&ISO^XX^^^123544|3.6.23|A-1 Lab System|6742873-12||20100617
PID|1||PATID1234^^^&2.16.840.1.113883.3.72.5.24&ISO^MR^Seminole Cnty Hlth C&2.16.840.1.113883.3.0&ISO||Jones^William^A^^^^L||19610615|M||2106-3^White^CDCREC|1955 Seminole Lane^^Oveido^FL^32765^USA^H^^12059||^PRN^PH^^1^407^2351234||||||||N^Not Hispanic or Latino^HL70189^NL^not latino^L^2.5.1
ORC|RE|ORD723222-4^^2.16.840.1.113883.3.72.5.24^ISO|R-783274-4^LIS^2.16.840.1.113883.3.72.5.25^ISO|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI||^PRN^PH^^^407^2341212||||||Seminole County Health Clinic|555 Orange Ave^^Oviedo^FL^32765^^B|^WPN^PH^^^813^8847284|555 Orange Ave^^Oviedo^FL^32765^^B
OBR|1|ORD723222-4^^2.16.840.1.113883.3.72.5.24^ISO|R-783274-4^LIS^2.16.840.1.113883.3.72.5.25^ISO|625-4^Bacteria identified in Stool by Culture^LN^3456543^CULTURE
STOOL^99USI^2.40|||20110528|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI|^PRN^PH^^^407^2341212|||||201106010900-0500|||F
OBX|1|CWE|625-4^Bacteria identified in Stool by Culture^LN^Bacteria identified^Bacteria identified^99USI^2.40|1|85729005^Shigella flexneri^SCT^^^^^^Shigella flexneri|||||F|||20110528|||||20110531130655-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI

OBX|1|CWE|625-4^Bacteria identified in Stool by Culture^LN^Bacteria identified^Bacteria identified^99USI^2.40|2|66543000^Campylobacter jejuni^SCT^^^^^^Campylobacter jejuni||||||F|||20110528|||||20110531130655-0500|||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
SPM|1|^ORD723222-4&&2.16.840.1.113883.3.72.5.24&ISO||119339001^Stool specimen^SCT^^^^07/31/2012||||||||||||20110528|20110529
OBR|2||R-783274-5^LIS^2.16.840.1.113883.3.72.5.25^ISO|50545-3^Bacterial susceptibility panel in Isolate by Minimum inhibitory concentration (MIC)^LN^Bact suscept^Bacteria susceptibility^99USI^2.40|||20110528|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI|^PRN^PH^^^407^2341212|||||201106010900-0500|||F|625-4&Bacteria identified in Stool by Culture&LN&Bacteria identified&Bacteria identified&99USI^1^Shigella flexneri|||^R-783274-4&LIS&2.16.840.1.113883.3.72.5.25&ISO
OBX|1|SN|20-8^Amoxicillin+Clavulanate [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^AmoxClav^Amoxicillin-clavulanic acid^99USI^2.40||=^16|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||I^Intermediate^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|2|SN|516-5^Trimethoprim+Sulfamethoxazole [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^TMP-SMX^Trimethoprim-sulfamethoxazole^99USI^2.40||=^8^/^152|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||R^Resistant^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|3|SN|185-9^Ciprofloxacin [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^CIPROFLOXACIN^CIPROFLOXACIN^99USI^2.40||<=^0.06|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||S^Susceptible^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI

OBR|2||R-783274-5^LIS^2.16.840.1.113883.3.72.5.25^ISO|50545-3^Bacterial susceptibility panel in Isolate by Minimum inhibitory concentration (MIC)^LN^Bact suscept^Bacteria susceptibility^99USI^2.40|||20110528|||||||||57422^RADON^NICHOLAS^^^Dr.^^^NPI&2.16.840.1.113883.4.6&ISO^L^^^NPI|^PRN^PH^^^407^2341212|||||201106010900-0500|||F|625-4&Bacteria identified in Stool by Culture&LN&Bacteria identified&Bacteria identified&99USI^2^Campylobacter jejuni|||^R-783274-4&LIS&2.16.840.1.113883.3.72.5.25&ISO
OBX|1|SN|20-8^Amoxicillin+Clavulanate [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^AmoxClav^Amoxicillin-clavulanic acid^99USI^2.40||>=^32|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||R^Resistant^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|2|SN|516-5^Trimethoprim+Sulfamethoxazole [Susceptibility] by Minimum inhibitory concentration (MIC)^LN^TMP-SMX^Trimethoprim-sulfamethoxazole^99USI^2.40||=^8^/^152|ug/mL^microgram per milliliter^UCUM^^^^1.8.2||R^Resistant^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-0500||||Seminole County Health Department Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida

Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI
OBX|3|SN|185-9^Ciprofloxacin [Susceptibility] by Minimum inhibitory concentration
(MIC)^LN^CIPROFLOXACIN^CIPROFLOXACIN^99USI^2.40||<=^0.25|ug/mL^microgram per
milliliter^UCUM^^^^1.8.2||S^Susceptible^HL70078^^^^2.5.1|||F|||20110528|||||201106010900-
0500||||Seminole County Health Department
Laboratory^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^XX^^^987|6756 Florida
Avenue^^Oveido^FL^32765^^B|10092^Pafford^Hamlin^^^^^^&2.16.840.1.113883.3.72.5.30.1&ISO^L^^^NPI