



Implementation of National Standards (LOINC, SNOMED) for Electronic Reporting of Laboratory Results: BioSense Experience

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The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official positions of the Centers for Disease Control and Prevention

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Outline



- Background/purpose
- Data sources
- Transmission of data
- Processing and use of data at CDC
- Use of standard test codes (LOINC)
- Use of standard result codes (SNOMED)
- Conclusions and recommendations for implementing standards

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Background



- The BioSense system receives data from >400 non-federal hospitals, including 50 that send microbiology laboratory tests and results and from a national laboratory.
- Before transmission to CDC, local test codes are mapped to LOINC codes and local result codes to SNOMED.
- At CDC, SNOMED and LOINC codes are mapped to notifiable conditions using updated versions of standard mapping tables

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Objectives



- Describe the laboratory surveillance component of BioSense
- Review laboratories' practices for reporting microbiology results
- Describe the implementation of national standards for reporting laboratory tests and results
- Based on BioSense laboratory experience, identify possible improvement activities for the implementation of standards

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Methods: Data sources



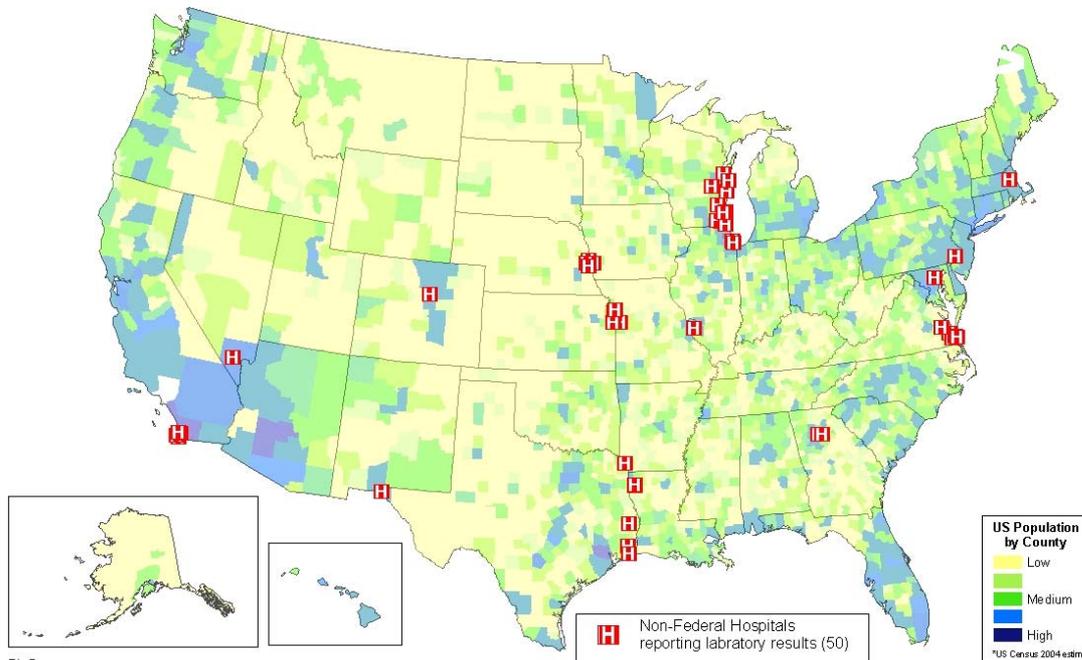
- Data sources
 - Hospital laboratories (n=50)
 - Approximately 34,000 orders are received per day
 - Linked to other BioSense data via a random number patient identifier
 - National laboratory
 - Approximately 160,000 test orders per day from more 80,000 providers, primarily outpatient physicians and small group practices
 - These results are unlinked to other data on individual patients
 - Not included in this presentation

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Data Sources: Hospital Laboratories Reporting to BioSense



BioSense
Division of Emergency Preparedness and Response
National Center for Public Health Informatics
Centers for Disease Control and Prevention

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Methods: Data Transmission



- Data transmission: laboratory data sent to CDC via the Public Health Information Network Messaging System (PHINMS) using HL7 2.5 messages.
- PHIN Messaging Standard “Electronic Laboratory Message, ORU^R01”, v.2.5.1. was implemented
- BioSense data transmission standards were developed:
 - BioSense Data Messaging Guide
 - BioSense Mapping Tool

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Methods: Data Processing and Analysis



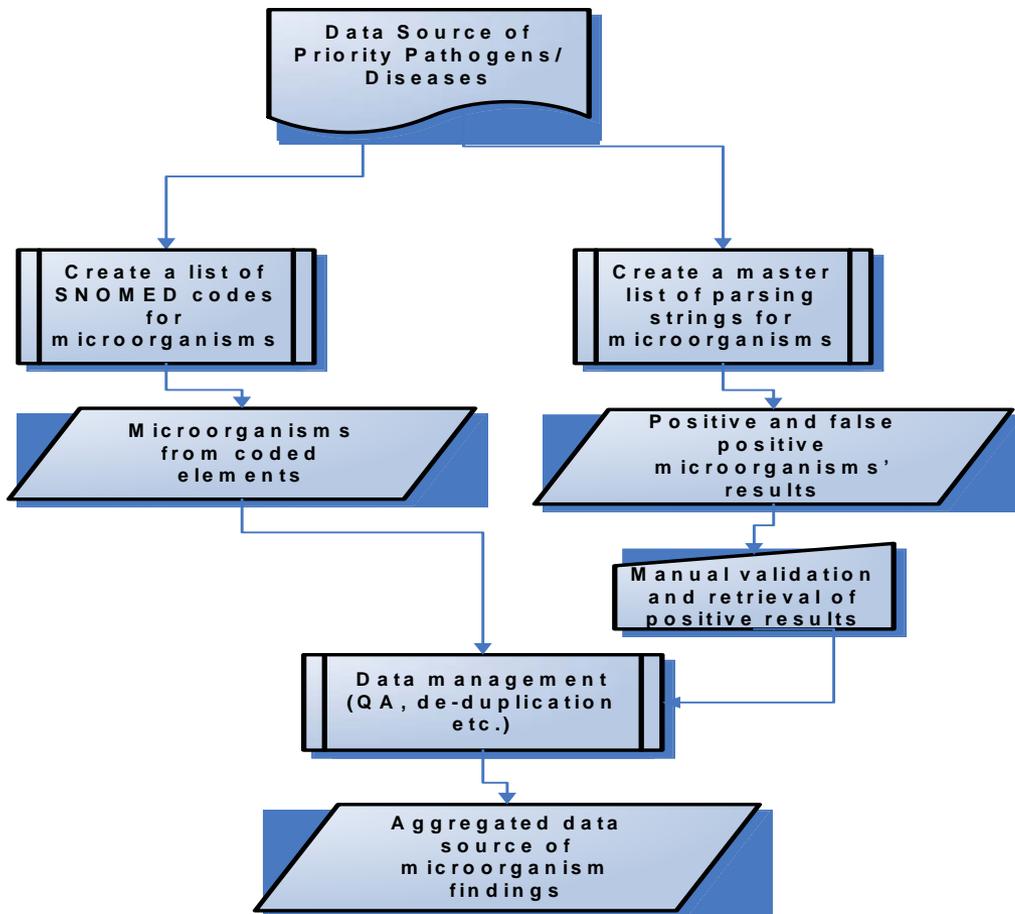
- Analyzed microbiology laboratory data from >599,000 patients during January 2007 and August 2008 from 50 hospital laboratories.
- Evaluated the results of mapping of local codes to standard
 - Laboratory tests (Logical Observation Identifiers Names and Codes, LOINC)
 - Laboratory results (The Systematized Nomenclature of Medicine, Clinical Terms, SNOMED CT)
- Used RELMA (Regenstrief Institute, 2007) for validation of LOINC codes and CliniClue browser (Clinical Information Consultancy, 2008) for validation of SNOMED CT codes

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Data Processing: Process Flow



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Data Processing and Analysis: SNOMED to Notifiable Conditions Table—Modified for BioSense



Includes SNOMED codes for 162 conditions, including notifiable conditions and other pathogens of interest (e.g., influenza, RSV, MRSA)

Example of conditions included in table

Condition Name
AIDS HIV infection, adult HIV infection, pediatric
Acinetobacter infections
Amebiasis
Anthrax
Arbovirus infection
Arbovirus infection Colorado tick fever
Arbovirus infection Dengue Fever
Arbovirus infection Encephalitis/meningitis, California serogroup viral
Arbovirus infection Encephalitis/meningitis, Powassan
Arbovirus infection Encephalitis/meningitis, St. Louis
Arbovirus infection Encephalitis/meningitis, Venezuelan equine (VEE)
Arbovirus infection Encephalitis/meningitis, West Nile
Arbovirus infection Encephalitis/meningitis, eastern equine (EEE)
Arbovirus infection Encephalitis/meningitis, western equine (WEE)
Arbovirus infection Yellow fever
Babesiosis
Bacillus cereus infections, not B. anthracis
Bacillus subtilis infection
Bacteroides fragilis infection
Beta-hemolytic Streptococcus
Beta-hemolytic Streptococcus Streptococcus pyogenes
Beta-hemolytic Streptococcus Streptococcus, group C
Beta-hemolytic Streptococcus Streptococcus, group F
Beta-hemolytic Streptococcus Streptococcus, group G
Blastomycosis
Blastomycosis dermatitidis infection
Blastomycosis
Botulism, other unspecified
Brucellosis
Burkholderia cepacia complex (BBC) infection
Campylobacteriosis
Candidiasis
Chancroid
Chlamydia trachomatis genital infection
Cholera (toxigenic Vibrio cholerae 01 or 0139)
Cholera (toxigenic Vibrio cholerae 01 or 0139) Vibrio spp., non-toxigenic, other or unspecified
Citrobacter
Clostridium difficile
Clostridium perfringens
Coccidioidomycosis

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Tracking Notifiable Diseases Using Local Codes Mapped to Standard SNOMED Codes (Pilot Project)



Visit ID	Notifiable	Risk Condition	Observation Results	Obs Result Code	Date of Collection	Result Status	Facility Name	State	Region
1837708^1128	Yes	Tuberculosis	StdCode=113858008, StdDesc=Mycobacterium tuberculosis complex (organism), StdCodingSys=SNOMED, (LocalCode=, LocalDesc=Mycobacterium tuberculosis complex)	113858008	04/25/2008	P	Hospital		East North Central
1903045^1128	Yes	Chlamydia trachomatis genital infection	StdCode=63938009, StdDesc=Chlamydia trachomatis (organism), StdCodingSys=SNOMED, (LocalCode=, LocalDesc=Chlamydia trachomatis)	63938009	05/14/2008	F	Hospital		East North Central
1914538^1128	Yes	Streptococcus pneumoniae	StdCode=9861002, StdDesc=Streptococcus pneumoniae (organism), StdCodingSys=SNOMED, (LocalCode=, LocalDesc=Streptococcus pneumoniae)	9861002	05/20/2008	P	Hospital		East North Central

BioSense maps positive results from laboratories that implemented local or standard result test codes

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Using Text String Results (Pilot Project)



Visit ID	Risk Condition	Observation Results	Date of Collection	Result Status	Facility Name	State	Region
444690 ^1133	Typhoid Fever? Typhus Fever? Paratyphoid Fever?	<p>PROCEDURE: STOOL CULTURE SOURCE: Stool COLLECTED: 07/08/2007 15:20 BODY SITE: Stool STARTED: 07/08/2007 15:38 FREE TEXT SOURCE: ACCESSION: 07- 189-01678 *** AMENDED REPORT *** Amended Final Report Verified: 07/20/2007 16:29 Moderate growth SALMONELLA SEROTYPE typhimurium Phoned report to: Dr. xxx 7/11/2007 07:00 AM by xxx Organism sent to State Lab for confirmation. *** SUSCEPTIBILITY RESULTS *** Salmonella species MDIL MINT Ampicillin 16 I Ciprofloxacin <=0.5 S Trimethoprim/Sulfa <=0.5/9.5 S Salmonella species</p> <p style="text-align: center;">Ampicillin</p> <p>MINT corrected from R on 07/20/2007 16:26 S=Susceptible, I=Intermediate, R=Resistant, N/A=Not Applicable</p>	07/20/ 2007	F	xxxxx		Mountai n

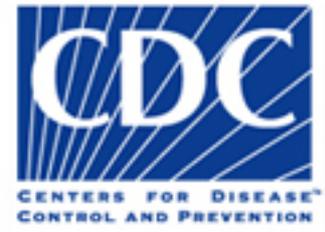
BioSense tracks about 20 of the most important notifiable diseases using natural language processing (NLP) methods

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Mapping of Local Codes to Standard LOINC—Ordered Tests

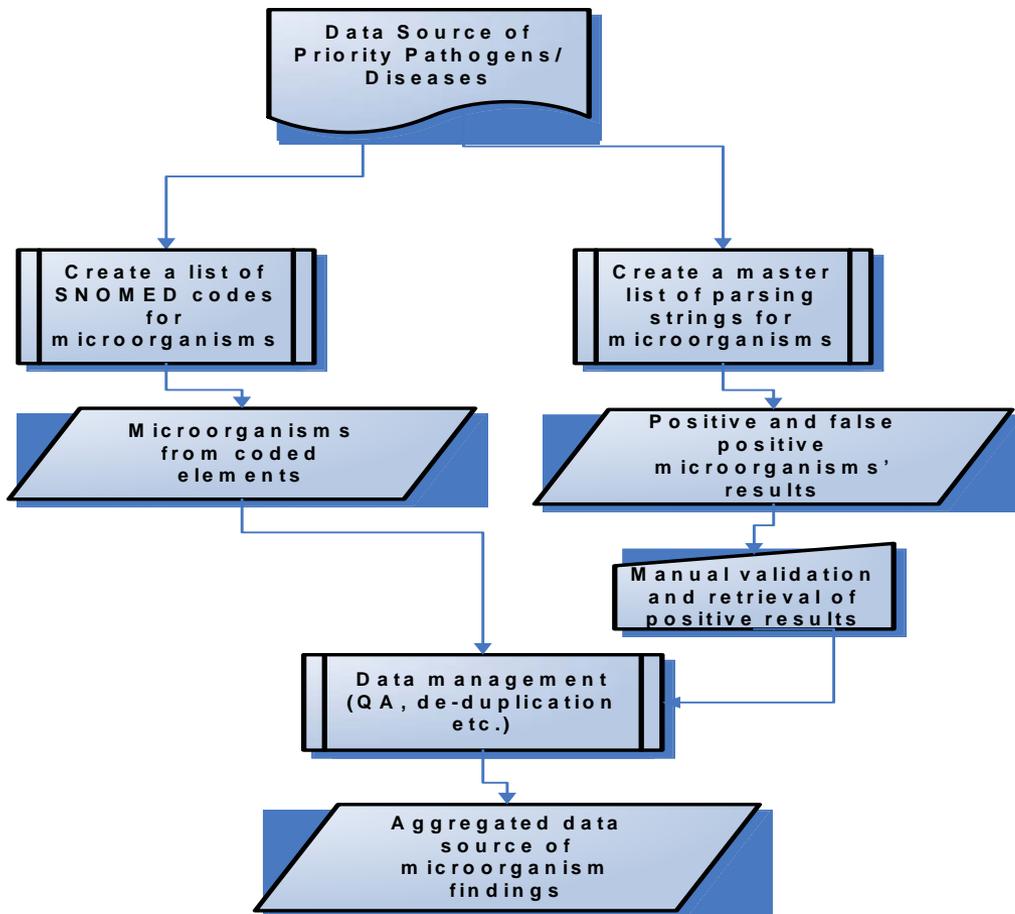


- All hospital laboratories use local codes which are mapped to standard codes at the source
- 1,874 local ordered tests were mapped to 586 LOINC (ratio1:3.5).
- Major causes of a reduction of codes:
 - Labs use different local codes/names for the same standard procedure
 - Problems with translation of local codes to LOINC
 - Problems with mapping

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Data Processing: Process Flow



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Mapping of Ordered Tests to Other



31.3% of local codes are not mapped to LOINC or mapped as “Other”

Examples of problems with direct mapping to LOINC of ordered test names.

Local test order		LOINC	
Code	Name	Code	Name
005462	Panel 005462		
140970	PACKAGE 15		
289090	Panel 289090		
4677103	BACTERIAL PFGE	OTH	Other
4677107	LEGIONELLA PCR	OTH	Other

Local test order Legionella PCR does not have exact match in the LOINC coding system

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Mapping of Local Codes to Standard LOINC—Resulted Tests



- All hospital laboratories use local codes which are mapped to standard (LOINC) codes at the source
- Result test names tend to be more detailed than ordered tests; there were 2,505 unique local result test names vs. 1,874 ordered tests
- The resulted test name is different in 41.3% of tests and conveys more specific information

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Mapping of Local Codes to Standard LOINC—Resulted Tests



Resulted test names frequently convey more specific information than ordered tests

Example. Translation of a local ordered microbial susceptibility test into resulted tests

Local test order		Local test result	
Code	Name	Code	Name
KBGPC	GPC - Kirby Bauer	AM	Ampicillin
KBGPC	GPC - Kirby Bauer	CF	Cephalothin
KBGPC	GPC - Kirby Bauer	E	Erythromycin
KBGPC	GPC - Kirby Bauer	GM	Gentamicin
KBGPC	GPC - Kirby Bauer	LEV	Levofloxacin
KBGPC	GPC - Kirby Bauer	FT	Nitrofurantoin
KBGPC	GPC - Kirby Bauer	OX1	Oxacillin
KBGPC	GPC - Kirby Bauer	PEN	Penicillin
KBGPC	GPC - Kirby Bauer	TE	Tetracycline
KBGPC	GPC - Kirby Bauer	SXT	Trimethoprim+Sulfamethoxazole

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Mapping of Local Codes to Standard LOINC—Resulted Tests



There are different local test names for the same procedure; mapping of local result tests to LOINC caused reduction of tests more than 2.3 times; 2,505 local result test codes were mapped to 1,070 LOINC

Example.

Local result codes/descriptions used by different hospitals for a standard (LOINC) test procedure 13317-3, “Staphylococcus aureus.methicillin resistant isolate:ACnc:Pt:XXX:Ord:Organism specific culture “

Local result code	Local result text
182253	MRSA Culture/Susceptibility
295	MRSA SCREEN
6211173	C MRSA
6211173	C STAAUR
CMRSA	MRSA CULTURE
CMRSA	MRSA Screen
CULMRSA	Culture MRSA Screen
CXMRS	CULTURE MRSA
ICMRSA	Inf Cntrl MRSA Screen
MRSA	MRSA SCREEN CULTURE

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Susceptibility Test Results



31 of 50 labs (62.0%) use local result codes for antimicrobial susceptibility. These are mapped to standard (LOINC) codes

Example

Result Test Code (LOINC)	Result Test Name (LOINC)
18864-9	Ampicillin:Susc:Pt:Isolate:OrdQn:
18900-1	Cephalothin:Susc:Pt:Isolate:OrdQn:
18919-1	Erythromycin:Susc:Pt:Isolate:OrdQn:
18928-2	Gentamicin:Susc:Pt:Isolate:OrdQn:
20629-2	Levofloxacin:Susc:Pt:Isolate:OrdQn:
18955-5	Nitrofurantoin:Susc:Pt:Isolate:OrdQn:
18961-3	Oxacillin:Susc:Pt:Isolate:OrdQn:
18964-7	Penicillin:Susc:Pt:Isolate:OrdQn:
18993-6	Tetracycline:Susc:Pt:Isolate:OrdQn:
18998-5	Trimethoprim+Sulfamethoxazole:Susc:Pt:Isolate:OrdQn:

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Use of LOINC Codes for Recognizing Notifiable Diseases



Ten most frequent LOINC codes comprise almost 67% of test results

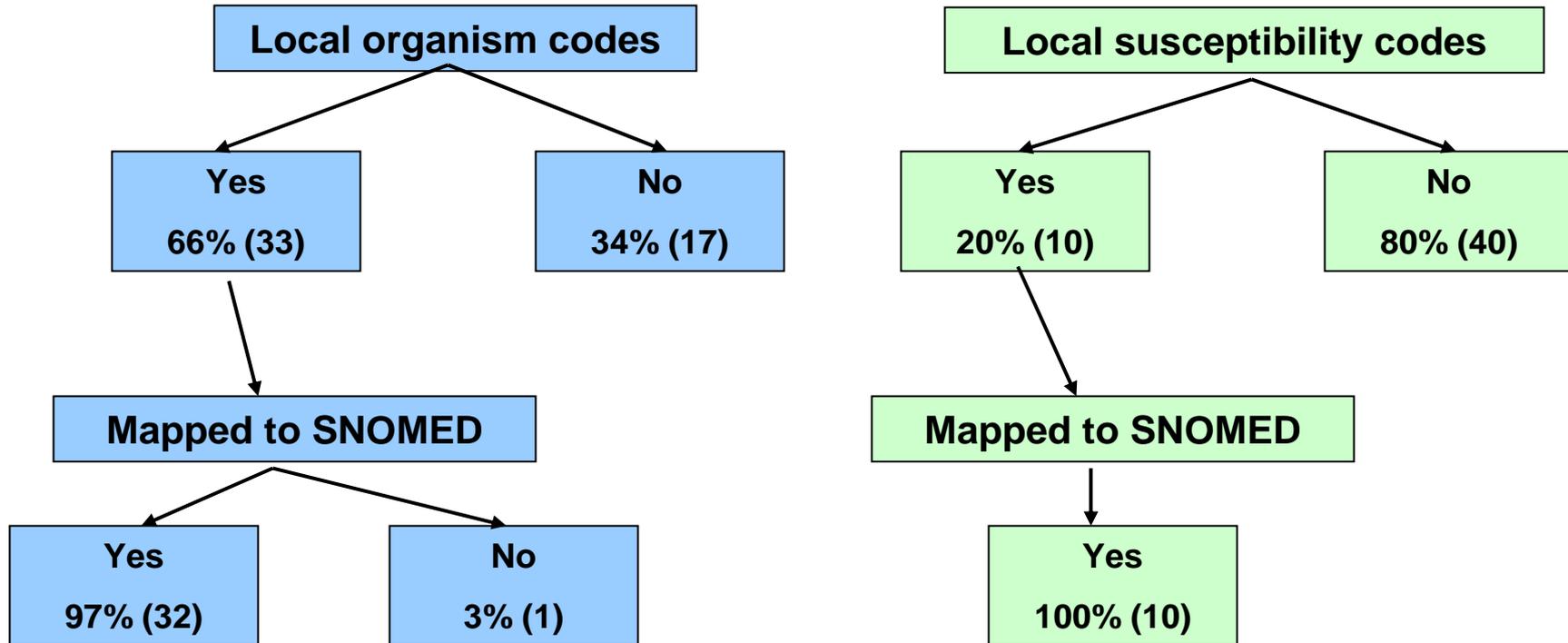
LOINC code	LOINC name	%
OTHER + not coded	N/A	18.6%
600-7	Bacteria identified:Prid:Pt:Bid:Nom:Culture	9.5%
33511-7	APPEARANCE:APER:PT:XXX:NOM:	8.0%
11475-1	MICROORGANISM IDENTIFIED:PRID:PT:XXX:NOM:CULTURE	7.6%
31208-2	Specimen source:Prid:Pt:XXX:Nom:	6.5%
664-3	Microscopic observation:Prid:Pt:XXX:Nom:Gram stain	4.8%
41741-0	MICROORGANISM IDENTIFIED:PRID:PT:XXX:NOM:	4.5%
630-4	Bacteria identified:Prid:Pt:Urine:Nom:Culture	3.8%
8251-1	SERVICE COMMENT 01:IMP:PT:XXX:NOM:	2.0%
42806-0	MICROORGANISM IDENTIFIED:PRID:PT:ISLT:NOM:	1.5%

- Almost 19% of LOINC codes are “Other” (local tests can not be directly mapped to LOINC)
- LOINC codes describe general routine procedures based on cultures (i.e., blood culture, urine culture etc.)
- For tracking notifiable diseases, in most cases LOINC test names are not specific enough w/o additional information
- There are situations when laboratories use two-fold descriptors of positive results: they describe properties of microorganism using SNOMED codes not specific to a microorganism (such as “Heavy growth”, “Positive” etc.) ; also, they use specific LOINC codes to describe a microorganism; for these situations LOINC codes are very useful for tracking of microorganisms

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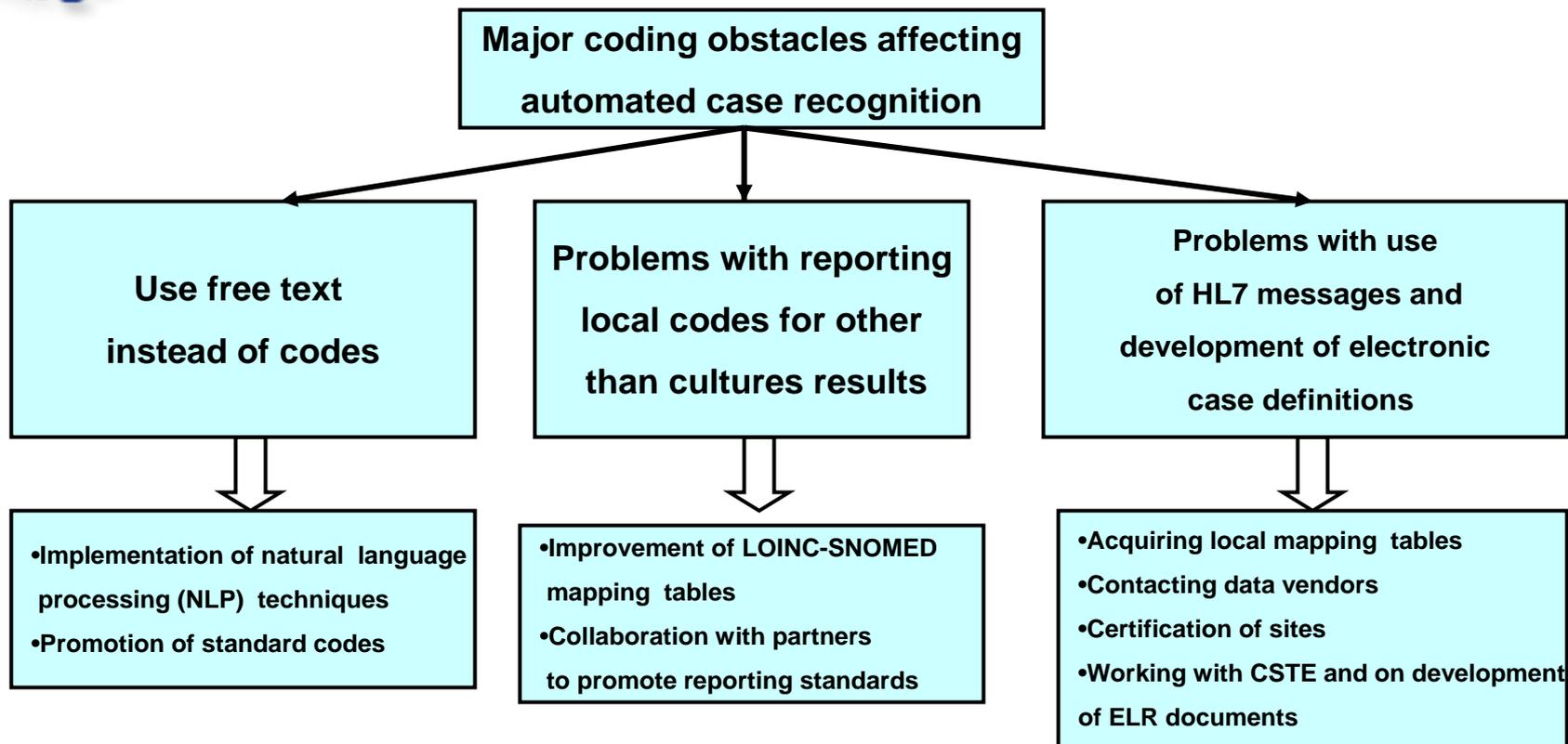
SNOMED-CT for Reporting Laboratory Test Results



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Overcoming Obstacles In Implementing SNOMED-CT Codes For Reporting of Laboratory Test Results



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Approach to Mapping Lab Criteria to Standard Codes



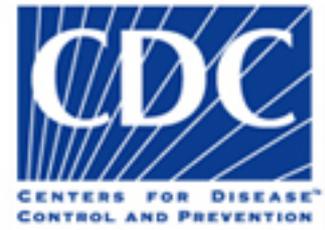
NNDSS	Disease	Laboratory Criteria	Sub-Code	LOINC (TBD)
10020	Brucellosis	Isolation of <i>Brucella</i> spp. from a clinical specimen, or	10020-1	
		Fourfold or greater rise in <i>Brucella</i> agglutination titer between acute- and convalescent-phase serum specimens obtained greater than or equal to 2 weeks apart and studied at the same laboratory, or	10020-2	
		Demonstration by immunofluorescence of <i>Brucella</i> spp. in a clinical specimen	10020-3	

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Problems with Reporting Local Codes for Results Other Than Cultures



>42,000 laboratory test codes (LOINC) mapped by PHIN VADS to 12,000 organism codes (SNOMED)

>12,900 LOINC tests for antibodies, antigens and DNA (27%); most have no corresponding local test codes and therefore could not be mapped to SNOMED codes.

Currently the BioSense data feed contains 840 microorganism-related SNOMED codes

Example. Mapping Measles Case Definition Criteria to LOINC and SNOMED Codes (Excerpt)

CSTE case criterion	LOINC Test Code	LOINC test name	SNOMED Result Code	SNOMED text
2. PCR, measles-specific RNA	48508-6	Measles virus RNA	117277004	Measles virus RNA
	7964-0	Measles virus RNA	117277004	Measles virus RNA
3. Measles IgM test	13283-7	Measles virus Ab.IgM	168276008	Serology positive
	21502-0	Measles virus Ab.IgM	168276008	Serology positive
	21503-8	Measles virus Ab.IgM	168276008	Serology positive
	22505-2	Measles virus Ab.IgM	168276008	Serology positive
	5245-6	Measles virus Ab.IgM	168276008	Serology positive
	7963-2	Measles virus Ab.IgM	168276008	Serology positive
4.Acute serum for measles	14304-0	Measles virus Ab.IgG^1st specimen	168276008	Serology positive
	17555-4	Measles virus Ab^1st specimen	168276008	Serology positive
	22503-7	Measles virus Ab.IgG^1st specimen	168276008	Serology positive
	25299-9	Measles virus Ab.IgG^1st specimen/2nd specin	168276008	Serology positive

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Overcoming Obstacles in Implementation of SNOMED-CT Codes for Reporting Laboratory Test Results



Development of local data dictionaries/SNOMED mapping tables (also, similar tables for LOINC)

Example. Fragment of a local data dictionary that was successfully mapped to SNOMED

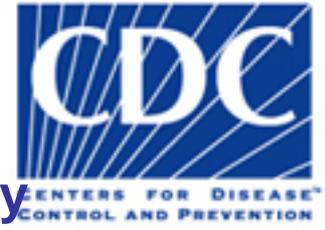
Local code	Local code description	SNOMED concept id	SNOMED preferred term
ACCL	ACINETOBACTER CALCOACETICUS VAR. LWOFFI	83088009	Acinetobacter lwoffii
ACHR	ACHROMOBACTER SPECIES	413423003	Achromobacter species
ACIN	ACINETOBACTER SPECIES	116456006	Acinetobacter species
ACLA	ASPERGILLUS CLAVATUS	87240002	Aspergillus clavatus
ACODO	ACTINOMYCES ODONTOLYTICUS	12069003	Actinomyces odontolyticus

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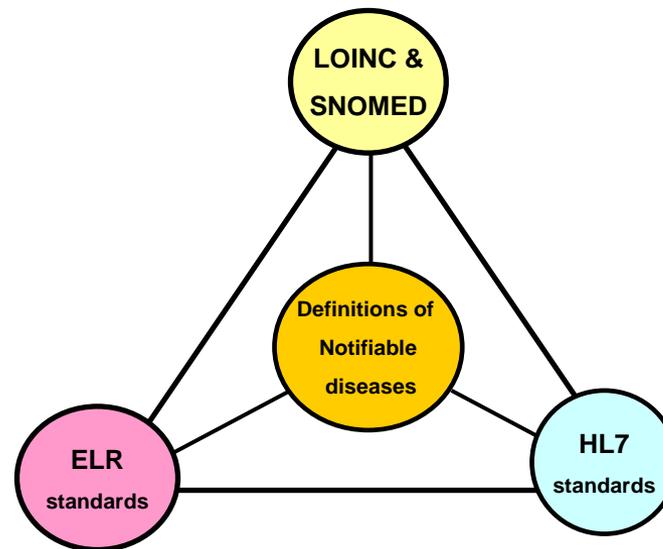


Implementation of National Standards (LOINC, SNOMED) for Electronic Reporting of Laboratory Results: Next Steps



1. Working with CDC, CSTE and other partners on development of qualitative and quantitative laboratory indicators for recognition of notifiable diseases under public health surveillance

2. Strengthening cross-linkages between national guidelines for electronic reporting of notifiable diseases



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Conclusions

- Our analyses highlight the challenges of mapping local microbiology laboratory data to standard vocabularies
- BioSense experience may help as strategies for case recognition of notifiable diseases are being developed
- To make case definitions, vocabularies, and messaging standards work in concert:
 - Further development of electronic laboratory criteria for notifiable diseases
 - Use of standard codes locally, or more accurate mapping of local codes to standard
 - Development of new LOINC and SNOMED codes where needed

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Questions?



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Thank you

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