

SNOMED CT and Antimicrobial Stewardship

W. Scott Campbell PhD

Nicholas J. Staffend, MSEng

James R. Campbell MD



SERIOUS MEDICINE. EXTRAORDINARY CARE.™

Acknowledgements

Portions of this work have been funded by: NIH
5U01HG009455 Deploying ONC National Standards in
Support of Metadata for Big Data Research Warehouse
Management

The authors recognize the indispensable assistance of the
Nebraska Medicine Information Technology/Epic build team
and the Research Information Technology Office of UNMC

Olivier Bodenreider MD PhD and Robert Wynne of the US
National Library of Medicine kindly provided OWL renditions
and mapping between RXNORM and SNOMED CT

Jeffrey Wilcke DVM MS of Virginia Technical Institute maintains
the Organisms hierarchy for SNOMED International and
contributed to our enhancements of an organisms ontology



Antimicrobial Stewardship

- Coordinated program directing the appropriate use of antimicrobial drugs (e.g., antibiotics)
- Right drug to “bug”
- As narrowly targeted as possible
 - Save the broad spectrum, “heavy hitter” agents for only those cases when necessary
- Goal is to reduce multidrug antibiotic resistant organisms (MDRO)



Clinical Reality

- Patients present with symptoms of infection
- Identification of organism and antibiotic susceptibility information not immediately available (up to 48 hours)
- Antibiotic therapy must be started based on empiric data
- How is empiric data generated?



Antibiogram

- The antibiogram is a profile of the types of organisms and their antibiotic susceptibility patterns exhibited
- Required in the US and broadly encouraged by WHO
- Specific guidelines for calculation
- Historically, manually calculated
- Resource intensive
- Infrequent...not necessarily up to date

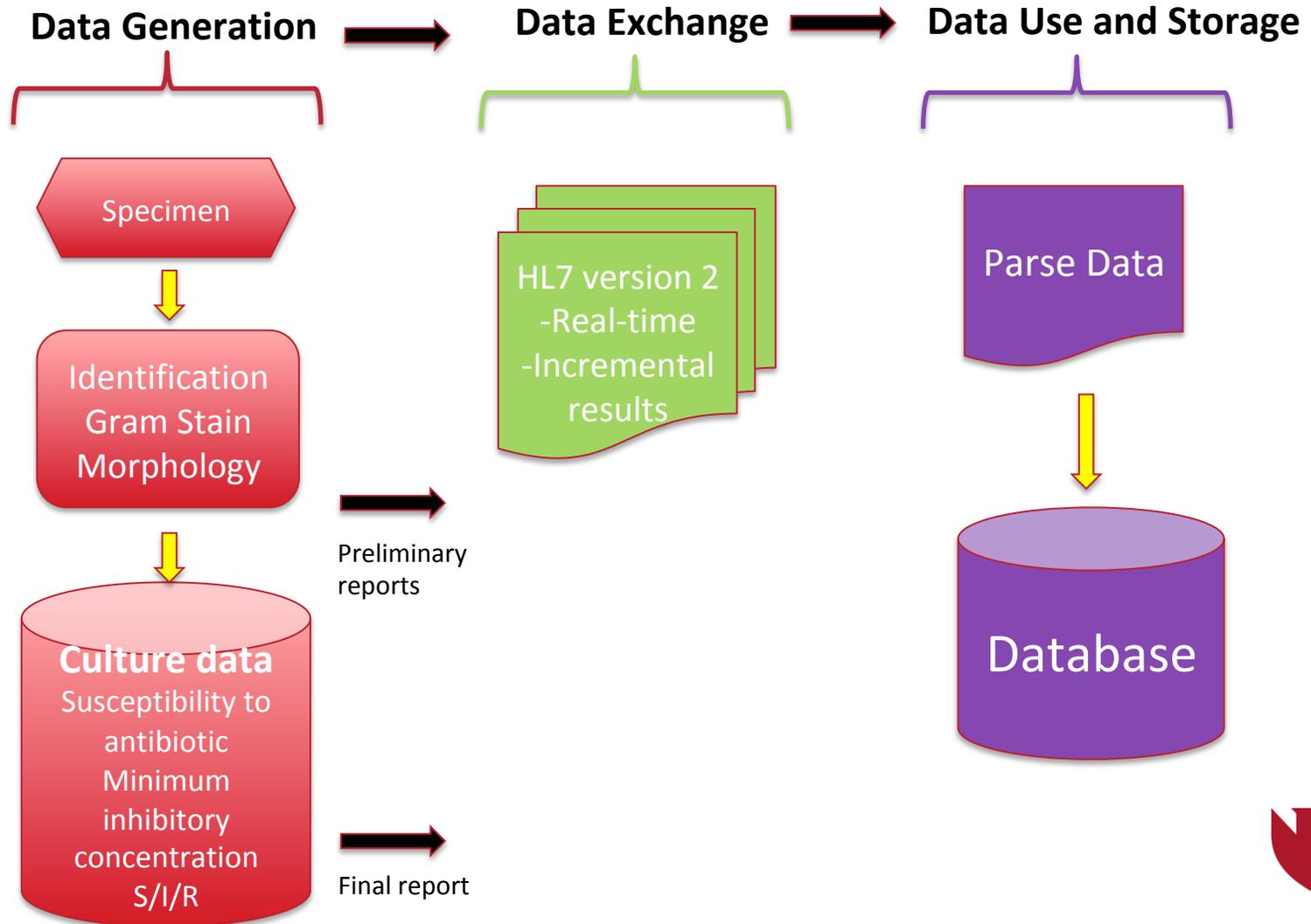


Automation and Standards

- Antibigrams based on laboratory culture data
- In US, electronic laboratory results data exchange is commonplace
- Meaningful Use efforts drove use of standards adoption
- Electronic, machine readable, encoded laboratory data can be used to automate the creation of the antibiogram and increase its utility



Micro Laboratory Data Flow



Sample Message Segment

- OBX|3|CWE|41852-5^MICROORGANISM/AGENT
XXX^LN^CULT^Culture Result:^SQLRR|1.2|
60875001^Staphylococcus epidermidis
(organism)^SCT^SEPI^Staphylococcus
epidermidis^L^^v1^Staphylococcus epidermidis
- SPM|1|S64958||122880004^Urine specimen obtained
by clean catch procedure
(specimen)^SCT^UCLN^Urine Clean Catch^L^^v1^Urine
Clean Catch|||||||||date|date
- OBX|3|SN|267-5^GENTAMICIN ISLT
MIC^LN^GM^Gentamicin^SQLRR|1.1|<=^1|||SS||F||
date|||50545-3^BACTERIAL SUSC PNL ISLT
MIC^LN^MIC^MIC^SQLRR||date|||

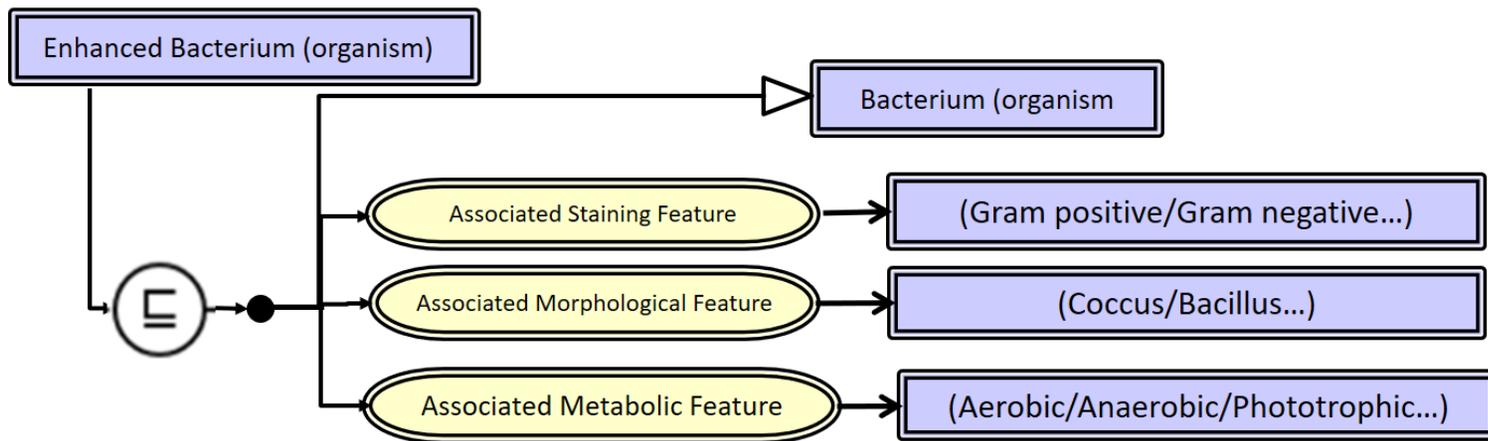


Standards

- LOINC: ontology created from LOINC-SNOMED collaboration agreement defining LOINC terms within SNOMED concept model
 - Lab orders and performed tests
- SNOMED CT
 - Specimen: sample type, procedure for sampling
 - Organism: enhanced with staining characteristics, morphology and metabolic features
- RxNorm: ontology developed by NLM employing SNOMED CT concept model
 - Pharmaceutical products, Substances



<<41146007|Bacterium| Ontology Enhancements

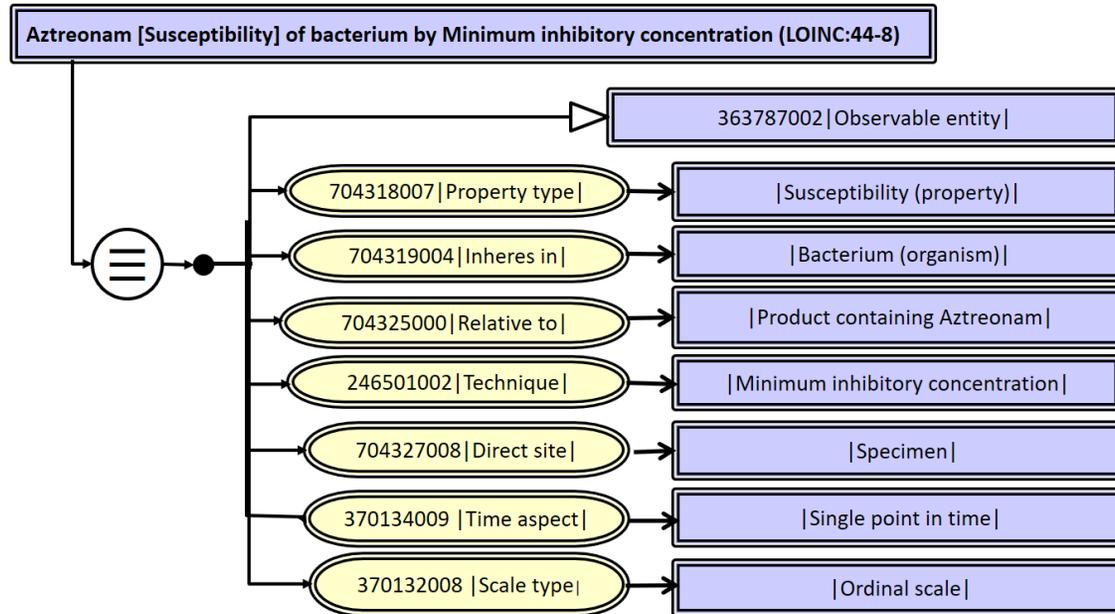


112283007 | *Escherichia coli* (organism) | :

- ✓ Associated Staining Feature: Gram negative
- ✓ Associated Morphological Feature: Bacillus
- ✓ Associated Metabolic Feature: Facultative anaerobic bacterium



LOINC (363787002|Observable entity|) Ontology Enhancements

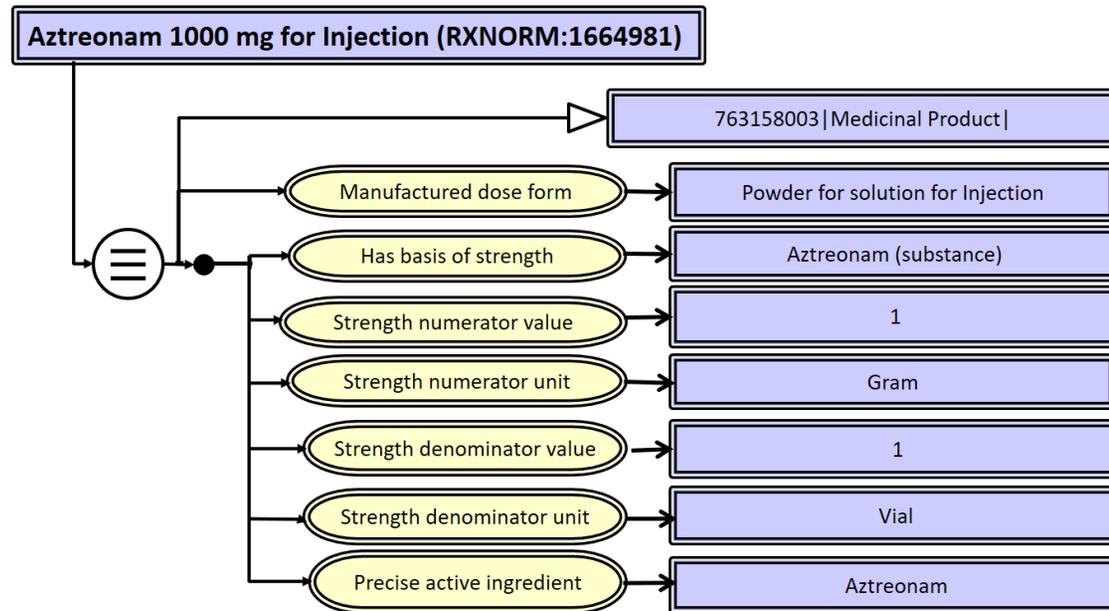


44-8 Aztreonam susceptibility of bacterium by MIC (observable entity) | :

- ✓ Property: Susceptibility
- ✓ Inheres in: Bacterium
- ✓ Relative to: Product containing Aztreonam
- ✓ Technique: Minimum inhibitory concentration



<<373873005 |Pharmaceutical / Biological Product|



Aztreonam 1000 mg Injection (RXNORM:1664981):

- ✓ Has precise active ingredient: Aztreonam
- ✓ Has presentation strength numerator: 1
- ✓ Has presentation strength numerator unit: Gram
- ✓ Has presentation strength denominator value: 1
- ✓ Has presentation strength denominator unit: Vial
- ✓ Has manufactured dose form: Powder for conventional solution for Injection



Nebraska Medicine: Status of Antibigram Deployment

- 22147 LOINC-on-OWL ontology concepts and groupers
- 756/1269 Enhanced <<41146007|Bacterium| concepts deployed in organism ontology
- 166 RXNORM concepts modelled for medication orders support
- Validated calculated susceptibilities against historical antibiograms published by UNMC for 2016-2019
- Since 2016, accrual of 350000 DRUG-BUG antibiogram facts per year from Sunquest lab reporting via HL7
- Average response time to user query 5 seconds
- Extended antibiogram support outside of hospital to ambulatory clinics and service areas
- “Cascading” antibiograms support detailed statistics for subpopulations of interest such as susceptibility of other antibiotics to ‘resistant’ bug



How Used in Antibiogram

- Specimen aggregation
 - Type of blood specimens
 - Line draw
 - Venipuncture
- Organism
 - Gram Stain (positive/negative)
 - Morphology
 - Metabolism (aerobic, anaerobic...)
 - Genus and species



Antibiogram for E coli - Inpatient units

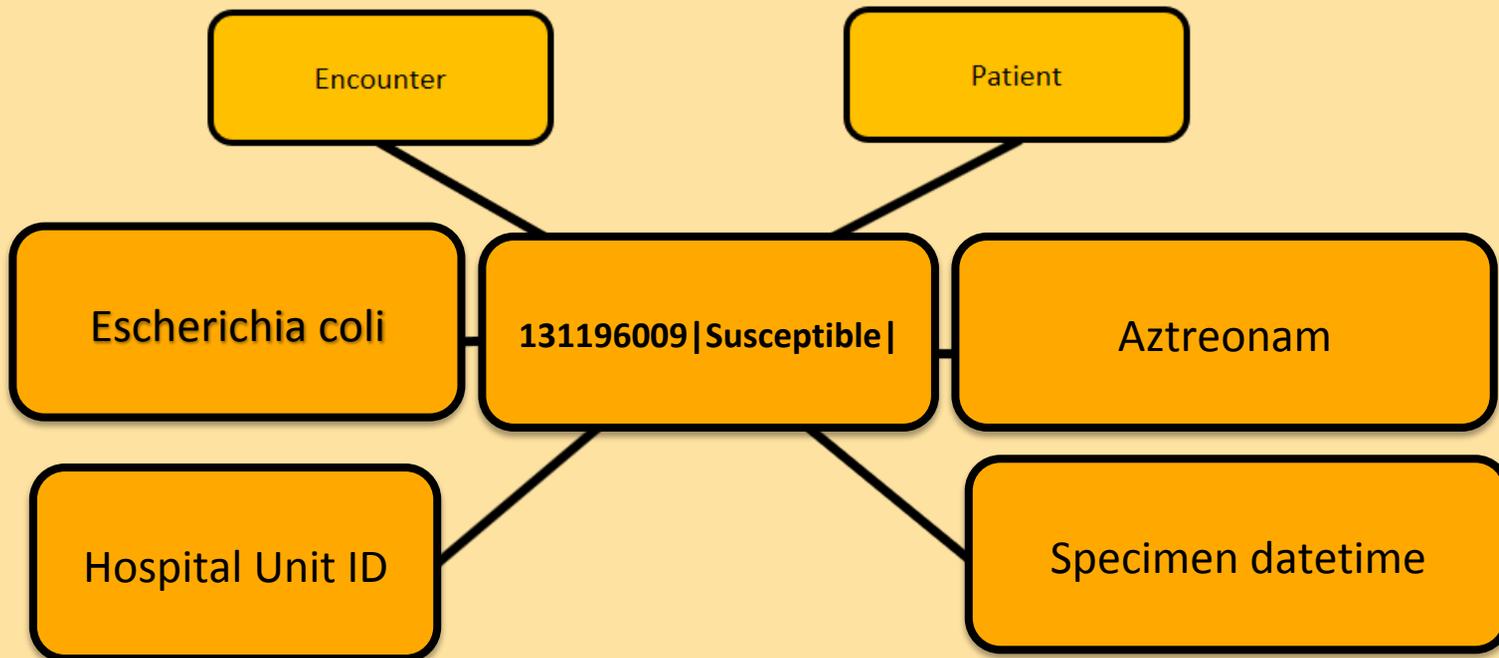
Time to build: 4.0125660896301

Antibiogram - All Inpatient

Organism	SctId	Antibiotic	Number	%S	Wilson Score
Escherichia coli	112283007	Amikacin	449	99.1	0.9744
Escherichia coli	112283007	Amp-Sulbactam	449	55	0.4972
Escherichia coli	112283007	Ampicillin	449	52.1	0.4684
Escherichia coli	112283007	Aztreonam	449	90.9	0.8735
Escherichia coli	112283007	Cefazolin	337	74.2	0.6851
Escherichia coli	112283007	Cefepime	449	91.1	0.8761

Antibiogram Facts

Microbial Susceptibility fact



Next steps

- Extending Terminologies to support specificity and CDSS
 - Organism management
 - Integration of susceptibility and NLM binding of RxNorm to SNOMED CT pharmaceuticals
- Integrate patient phenotyping
 - Transplanted patients
 - Cancer patients
- Integrate patient specific data
 - Renal function
 - Hepatic function
 - Comorbidities
 - Allergies
- Regional surveillance



Orderable Medications Ontology Enhancements

DL query:

Clinical Use Case:

What are the Aztreonam products in the US pharmacopoeia which can be ordered to treat E coli isolated from my patient?

- ⊖ Aztreonam (Azactam) 1000 mg for Injection (RXNORM1664984) ?
- ⊖ Aztreonam 1000 MG Injection (RXNORM1664981) ?
- ⊖ Aztreonam 2000 MG Injection (RXNORM1664986) ?
- ⊖ Aztreonam 75 MG/ML Inhalation Solution (RXNORM901610) ?
- Aztreonam 75mg powder for nebulizer solution (product) ?
- ⊖ Product containing precisely aztreonam 1 gram/1 vial powder for conventional release solution for injection (clinical drug) ?
- ⊖ Product containing precisely aztreonam 2 gram/1 vial powder for conventional release solution for injection (clinical drug) ?
- ⊖ Product containing precisely aztreonam 500 milligram/1 vial powder for conventional release solution for injection (clinical drug) ?



Orderable Medications Ontology Enhancements

DL query:

Query (class expression)

'Medicinal product (product)
and ('Role group (attribute)' some ('Has active ingredient (attribute)' some 'Aztreonam (substance)))

Execute

Add to ontology

Query results

Subclasses (9 of 9)

- ⊖ Aztreonam (Azactam) 1000 mg for Injection (RXNORM1664984) ?
- ⊖ Aztreonam 1000 MG Injection (RXNORM1664981) ?
- ⊖ Aztreonam 2000 MG Injection (RXNORM1664986) ?
- ⊖ Aztreonam 75 MG/ML Inhalation Solution (RXNORM901610) ?
- Aztreonam 75mg powder for nebulizer solution (product) ?
- ⊖ Product containing precisely aztreonam 1 gram/1 vial powder for conventional release solution for injection (clinical drug) ?
- ⊖ Product containing precisely aztreonam 2 gram/1 vial powder for conventional release solution for injection (clinical drug) ?
- ⊖ Product containing precisely aztreonam 500 milligram/1 vial powder for conventional release solution for injection (clinical drug) ?



Orderable Medications Ontology Enhancements

Clinical Use Case:

What are the Aztreonam products in the US pharmacopoeia which can be ordered to treat E coli isolated from my patient?

Clinical Use Case:

US orderable drugs:

- Aztreonam (Azactam) 1000 mg/vial injection
- Aztreonam (generic) 1000 mg/vial injection
- Aztreonam (generic) 2000 mg/vial injection



Conclusions

- Working, validated application
- Addressing key issue in AMS programs
- Example of Standards (broadly) used
- Surveillance tool framework
- Plan for increased incorporation of standards in support of CDSS





Nebraska Medicine

SERIOUS MEDICINE. EXTRAORDINARY CARE.®

