



Biomedical Informatics: Introduction and Definitions

Hadi Kharrazi *MHI MD PhD kharrazi@jhu.edu*

Johns Hopkins University

School of Public Health

School of Medicine

2 hrs / ~80 slides

Introduction

• Hadi Kharrazi, MHI, MD, PhD

Current affiliation: JHSPH-HPM (Aug 2012) Associate Director CPHIT *Director: Dr. J. Weiner*

Previous affiliation: Indiana University Dalhousie University

Research interests: Population Health IT

- CDSS/QM in HIE environments
- Personal Health Records (PHR)

Overview

- US Healthcare
 - General, Cost, Triple Aims
- Biomedical / Health Informatics
 - Concept & Definition
 - History
 - Subdomains
 - Data Sources
 - Systems
 - Methods
- ✤ Use Cases (population health examples)
 - Clinical
 - Consumer
 - Community / Population / Public

- Drivers
 - Incentives
 - Mandates
 - Facilitators
- Common Issues
 - Terminologies
 - Standards of Information Exchange
 - Usability Issues / Human Factors
 - Value-Added
- Resources
 - Books
 - Web



US Healthcare

US Healthcare – General

- At least 15.3% of the population is completely uninsured
- More money per person is spent on health care in the United States than in any other nation in the world
- Despite the fact that not all citizens are covered, the United States has the third highest public healthcare expenditure per capita
- Active debate about health care reform in the United States concerns questions of a right to health care, access, fairness, efficiency, cost, and quality
- The US pays twice as much yet lags behind other wealthy nations in such measures as infant mortality and life expectancy
- The US life expectancy lags 42nd in the world, after most rich nations, lagging last of the G5 (Japan, France, Germany, UK, USA) and just after Chile and Cuba.
- The World Health Organization (WHO), in 2000, ranked the US health care system as the highest in cost, first in responsiveness, 37th in overall performance, and 72nd by overall level of health (among 191 member nations included in the study)
- On March 23, 2010, the Patient Protection and Affordable Care Act became law, providing for major changes in health-insurance procedures

US Healthcare – **Cost** → **Historical**

- Current estimates put U.S. health care spending at approximately 16% of GDP. DHHS expects that the health share of GDP will reach 19.5% of GDP by 2017.
- Of each dollar spent on health care in the United States 31% goes to hospital care, 21% goes to physician services, 10% to pharmaceuticals, 8% to nursing homes, 7% to administrative costs, and 23% to all other categories.
- In 2007, the U.S. spent \$2.26 trillion on health care or \$7,439 per person.
- Medical causes were cited by about half of bankruptcy filers in the US in 2001.



Historical U.S. Healthcare Spending as % of GDP



US Healthcare – Cost \rightarrow Compare

US Healthcare – Cost \rightarrow Rise



Historical Healthcare Spending Rise

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Health Informatics Principles

Biomedical / Health Informatics – Concept & Definition

The science of information (Information = data with meaning / Humans will benefit from information)



- **Data** \rightarrow **Information** (who, when, where, what) \rightarrow **Knowledge** (how) \rightarrow **Wisdom** (why)
- AMIA's definition of HI → "Biomedical informatics (BMI) is the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making, motivated by efforts to improve human health."
- WHO's definition of eHealth → "Use of information and communication technologies for health for different purposes"
- HIMSS definition of eHealth → "Application of the Internet/other technologies to health care for various goals and objectives"
- Academic definition of HI → "A rapidly developing scientific field that deals with resources, devices, and formalized methods for optimizing the storage, retrieval, and management of biomedical information for problem solving and decision making."

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Health Informatics – Subdomains



Health Informatics – Subdomains \rightarrow Overlaps

• Some consider "population health informatics" a bridge to fill the gap between traditional clinical informatics and public health informatics.





Weiner, 2012 http://www.ijhpr.org/content/1/1/33



Health Informatics Systems

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Health Informatics – Systems

- Bioinformatics
- Provider/Clinical Informatics Systems
 - Common: EHR(EMR), CPOE
 - Specialty: LIS, RIS(PACS), e-Prescribing
 - Add-ons: CDSS
- Patient/Consumer Health Informatics
 - PHR
 - mHealth / Telehealth
- Payers/Insurer Informatics Systems
 - Claims, PBMs
 - Predictive Models
- Government Informatics Systems
 - National and State-level Databases
 - Public Health Systems (Surveillance)
 - Health Information Exchanges



Health Informatics – Systems \rightarrow Researchers \rightarrow Bioinformatics



Bioinformatics focus on biomolecules, DNA, RNA, proteins, networks and cells

Health Informatics – Systems → Provider → EHRs / CPOE



Electronic Health/Medical Record Systems (EHR) & Computerized Physician Order Entry Systems (CPOE)

Health Informatics – Systems \rightarrow Provider \rightarrow LIS / RIS (PACS)



Laboratory Information Systems (LIS) & Radiology Information Systems (RIS)

Health Informatics – Systems \rightarrow Patient/Consumer \rightarrow PHR



$Health\ Informatics - Systems \rightarrow Patient/Consumer \rightarrow mHealth$



mHealth (mobile health)

Health Informatics – Systems \rightarrow Patient/Consumer \rightarrow Telehealth



Tele-Health / Tele-medicine

Health Informatics – Systems → Payers → Claims / Predictive Modeling



Insurance Claims

Health Informatics – Systems \rightarrow Public/Government \rightarrow Biosurveillance



Health Informatics – Systems \rightarrow Public/Government \rightarrow HIEs



Concept of an Health Information Exchange







Health Informatics Methods

Health Informatics – Methods → Logic

- **Set Theory**: $x = \{a, b, c, d, e, f\} \& y = \{c, e\} \rightarrow y \subseteq x$
- **Boolean Logic**: AND, OR, XOR, NAND \rightarrow If/Then
- Venn Diagram



A B C (A AND B) OR C

- **Informal Logic**: certainty factors (e.g., MYCIN decision support)
- **Decision Tables**: representation of logic

Findings	Cı	C ₂	C ₃	C₄	C₅	C 6	C7	C ₈
f ₁	1	1	1	1	2	2	2	2
T2 f3	1	2	1^2	2	1	2	2 1	2
Actions								
<i>a</i> ₁	Х		Х	Х			Х	
a_2 a_3	Х	Х	Х	X X	X X		Х	Х
~								

Health Informatics – Methods → Probability

- **Statistics**: Inference, Prediction...
- **Bay's Rule**: Pr(A | B) = Pr(A)*Pr(B | A) / Pr(B)
- Bayesian Belief Networks: depicts the various dependencies in the form of an acyclic directed graph
- Decision Analysis: branching sequences of decision nodes and chance nodes





Health Informatics – Methods → IR/NLP

- User-Initiated:
 (1) Taxonomy-based (2) Free text
- Semi-automated or Automated:
 (1) D till to a fill to a fill

(1) Patient-specific (2) Context-specific (natural language processing)





Health Informatics – Methods → Expert Systems

Clinical Decision Support Systems:

- (1) input
- (2) inference engine
- (3) knowledge base
- (4) output



A general model of a clinical diagnostic decision support system

Health Informatics – Methods → Expert Systems (cont.)

Rule-based system:

(1) backward chaining (2) forward chaining



Forward Chaining Rule-bases CDSS
Health Informatics – Methods → Expert Systems (cont.)

Frame Based Systems:

- (1) Order sets
- (2) Treatment plans and others...

Patient #1		Patient #2		Patient #3	
Name	Robin Fox	Name	Anna Green	Name	Adam Plat
Sex	Male	Sex	Female	Sex	Male
DoB	1989/06/15	DoB	1976/11/18	DoB	1992/01/09
Diagnoses	Asthma	Diagnoses	Diabetes	Diagnoses	
Signs	Tachypnea	Signs		Signs	
Symptoms	Dispnea	Symptoms	Thurst	Symptoms	Headache
Treatments	Azmacort	Treatments	Sitagliptin	Treatments	

Sample Patient Frames

Health Informatics – Methods → Expert Systems (cont.)

Fuzzy Systems

1.0 Degree of membership Tall Short Average 0.0 160 170 180 150 190 200 210 (a) Helght, cm 1.0 Degree of membership 0.6 Short Tall Average 0.0 160 170 180 190 200 150 210 (b) Height, cm

Crisp vs Fuzzy systems

Health Informatics – Methods → Neural Networks

Inputs Artificial neural networks (ANN) are constructed in a fashion similar to X1 Linear Hard combiner limiter biological neural networks: (1) Single W_1 Output Layer ANN; (2) Multi-Layer ANN ► Y Synapse Soma Axon X2 Dendrites Synapse Threshold Architecture of a single neuron Axon Soma Dendrites Synapse **Biological neural network** Output signals nput signals **Biological neural network** Artificial neural network Soma Neuron Dendrite Input Output Axon Weight Synapse Input layer Middle layer Output layer

Analogy between biological and artificial NN

Architecture of a typical artificial neural network

Health Informatics – Methods → Genetic Algorithms / Evolutionary Computation

■ By iteratively extracting the best solutions, an optimal solution can be reached → challenge is creating the criteria which fitness is defined



Health Informatics – Methods → Genetic Programming (cont.)



Genetic algorithm cycle



Crossover in genetic programming

Health Informatics – Methods → Data Mining

- Data mining is the process of extracting patterns from data. Data mining is becoming an increasingly important tool to transform these data into information.
- Data mining can be used to uncover patterns in data but is often carried out only on samples of data. The mining process will be ineffective if the samples are not a good representation of the larger body of data → pattern validation is necessary.

Problem type	Description
Diagnosis	Inferring malfunctions of an object from its behaviour and recommending solutions.
Selection	Recommending the best option from a list of possible alternatives.
Prediction	Predicting the future behaviour of an object from its behaviour in the past.
Classification	Assigning an object to one of the defined classes.
Clustering	Dividing a heterogeneous group of objects into homogeneous subgroups.
Optimisation	Improving the quality of solutions until an optimal one is found.
Control	Governing the behaviour of an object to meet specified requirements in real-time.

Typical problems addressed by intelligent systems

Health Informatics – Methods → Big Data

- Big Data Specs data driven 4Vs:
 - Volume \rightarrow quantity (size)
 - Variety \rightarrow type (structure, standardized, ontology)
 - Veracity \rightarrow quality (meaning, completeness, accuracy)
 - Velocity \rightarrow time (real-time, timeliness)





Health Informatics Use Cases

Use Cases – Clinical / Public Health → Use of EHR data for Surveillance



Data sources for the electronic surveillance system for early notification of community-based epidemics (ESSENCE)

Copyright APL

Use Cases – Clinical / Public Health → Use of EHR data for Surveillance (cont.)



Processing for the electronic surveillance system for early notification of community-based epidemics (ESSENCE)

Copyright APL

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Use Cases – Consumer





And then shared it with your community

Copyright propellerhealth.com

Use Cases – Community \rightarrow Use of HIEs for Population Health



Calculating and Predicting Readmission to Hospitals

Copyright CRISP

Use Cases – Community → Use of HIEs for Population Health (cont.)

New Message	Check Mail Mark As Read - Move To Folder	- Delete -	Reply - Forward Print Save		
Inbox (4454)	Arranged by: Date, Descending +	at work	MRN: /// Emergency Dis	scharge	0
Sent Items Drafts	CRISP	Emergency Discharge 10:31 AM	(RESP + to (18:31 AM)		Show details
Trash	E · ///////////////////////////////////	Emergency Discharge 10:31 AM	Encounter Notifications		
Duplicates		Emergency Discharge 10:31 AM	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Notice: Risk of	0.207
	E · ///////////////////////////////////	Emergency Discharge 10:31 AM	EMERGENCY DISCHARGE	readmission for	83%
	E · ///////////////////////////////////	Inpatient Discharge 10:31 AM	Patient Information:	putient is nigh.	
	E · ///////////////////////////////////	Emergency Discharge 10:31 AM	Patient Name: ////////////////////////////////////		var1 55%
	CRISP	Inpatient Admission 10:31 AM	Address: ST		var2 85%
	E · 2///////////////////////////////////	Inpatient Discharge 10:31 AM	Hanne Phane: 301		var4 5%
	CRISP	Outpatient Discharge 10:31 AM	POP:		var5 100%
	E · ///////////////////////////////////	Inpatient Admission 10:31 AM	Hospital Name: Suburban Hospital Hospital MRN:		Simulate outcome
	E · ///////////////////////////////////	Inpatient Admission 10:31 AM	Event: Professor Discharge Event Time: 2012 9-44AM Admit Reason: R HAND INJURY		
	E · ZIIII	Outpatient Transfer 10:31 AM	Your Facility Site:		
	E · ZIIII	Emergency Discharge 10:31 AM	Your Facility MRN: Additional Info: VHR Portal Link		
	E · ///////////////////////////////////	Inpatient Admission 10:31 AM		Simulate a different outcom	e 🗵
	CRISP	Emergency Discharge 10:31 AM	You are revolving this message because you have requested 6	var1 55%	
	CRISP	Emergency Discharge 10:31 AM	Notifications from the statewide health information exchange I Any questions/concerns can be sent to: <u>abort.hieffortighealth.c</u>	var2 85%	0.20/
	CRISP	Emergency Discharge 10:31 AM		var3 20%	83%
	E · ///////////////////////////////////	Emergency Discharge 10:31 AM	and the	var5 100%	
Navage Fullers	E · ///////////////////////////////////	Inpatient Admission 10:31 AM	Lance states	Drag sliders to see the estimated effect on	readmission risk score
		123,65>>	Send Saye		

Advance Predicting Modeling Integrated in Encounter Notification Systems

Use Cases – Community → Use of HIEs for Population Health (cont.)



Inpatient Utilization By Census Tract – Neighborhood View (Capitol Heights Area)

Copyright CRISP



Drivers

Drivers

Incentives:

ARRA / HITECH \rightarrow (1) EHR adoption [Meaningful Use (MU) measures]; (2) state-wide HIEs; (3) Beacon Communities

Mandates:

ACA \rightarrow Payment Reforms \rightarrow PCMH and ACO initiatives \rightarrow Valuebased \rightarrow Capitated models \rightarrow Population health

Facilitation:

ONC \rightarrow Data Standards, integration, and sharing \rightarrow Distributed models



Drivers – **Incentive** → **EHR adoption** [Meaningful Use] (cont.)



Percentage of EHR systems among office-based physicians

Drivers – Mandate → Accountable Care Organizations (ACO)

- ACO are networks of providers with unifies governance that assume risk for the quality and total cost of the care they deliver.
- An ACO:
 - Authorization: **ACA** (2010)
 - Aims: **Triple Aims** (improve health, improve care, and lower cost)
 - Plans: **400**+ / Memberships: 4m
 - Leadership: **Physician-led** organizations
 - Focus: **Population** health management & **PCP**
 - Population: Considerable population (>5000) \rightarrow big data / provider variability
 - Contract: 3 years
 - Measures: Provide **quality benchmarking**, reporting, and tracking
 - Membership: **No patient lock-in** (in contrast with HMOs)
 - Financial: **Shared saving** (upward risk) and penalties (downward risk)
 - Future: Moving to the **global capitation model** / P4P
 - HIT Drivers: Meaningful Use (MU → EHR adoption → CDRs) and Health Information Exchanges (HIEs)



Drivers – Facilitate → ONC-HIT





HHS Organizational Chart

Drivers – Facilitate → Data Standards





Common Challenges

Common Issues → **Terminologies** / **Coding Systems** → **ICD**

 One of the best known terminologies is the International Classification of Diseases (ICD). First published in 1893, it has been revised at roughly 10-year intervals, first by the Statistical International Institute and later by the World Health Organization.

003 Other salmonella infections 003.2 Localized salmonella infections 003.22 Salmonella pneumonia * 020 Plague 020.3 Primary pneumonic plague 020.4 Secondary pneumonic plague 020.5 Pneumonic plague, unspecified 021 Tularemia 021.2 Pulmonary tularemia * 022 Anthrax 022.1 Pulmonary anthrax 481 Pneumococcal pneumonia 482 Other bacterial pneumonia 482.0 Pneumonia due to Klebsiella pneumoniae 482.1 Pneumonia due to Pseudomonas 482.2 Pneumonia due to Hemophilus influenzae 482.3 Pneumonia due to Streptococcus 482.30 Pneumonia due to Streptococcus, unspecified * 482.31 Pneumonia due to Group A Streptococcus * 482.32 Pneumonia due to Group B Streptococcus * 482.39 Other streptococcal pneumonia * 482.4 Pneumonia due to Staphylococcus 482.40 Pneumonia due to Staphylococcus, unspecified * 482.41 Pneumonia due to Staphylococcus aureus * 482.49 Other Staphylococcus pneumonia *

Examples of codes in ICD-9 and ICD-9-CM (*)

A01 Typhoid and paratyphoid fevers A01.0 Typhoid Fever A01.03 Typhoid Pneumonia * A02 Other salmonella infection A02.2 Localized salmonella infections A02.22 Salmonella pneumonia * A20 Plague A20.2 Pneumonic plague A22 Anthrax A22.1 Pulmonary anthrax A37 Whooping cough A37.0 Whooping cough due to Bordetella pertussis A37.01 Whooping cough due to Bordetella pertussis with pneumonia * A37.1 Whooping cough due to Bordetella parapertussis A37.11 Whooping cough due to Bordetella parapertussis with pneumonia * A37.8 Whooping cough due to other Bordetella species A37.81 Whooping cough due to other Bordetella species with pneumonia * A37.9 Whooping cough, unspecified A37.91 Whooping cough, unspecified species with pneumonia * A50 Congenital syphilis A50.0 Early congenital syphilis, symptomatic A 50.04 Early congenital syphilitic pneumonia * A54 Gonococcal infection A54.8 Other gonococcal infection A54.84 Gonococcal pneumonia * J13 Pneumonia due to Streptococcus pneumoniae J14 Pneumonia due to Hemophilus influenzae J15 Bacterial pneumonia, not elsewhere classified J15.0 Pneumonia due to Klebsiella pneumoniae J15.1 Pneumonia due to Pseudomonas J15.2 Pneumonia due to staphylococcus J15.20 Pneumonia due to staphylococcus, unspecified * J15.21 Pneumonia due to Staphylococcus aureus *

Examples of codes in ICD-10 and ICD-10-CM (*)

Common Issues → **Terminologies** / **Coding Systems** → **DRG**

 The coding system is an abstraction of an abstraction; it is applied to lists of ICD-9-CM codes that are themselves derived from medical records. The principal bases for the groupings are factors that affect cost and length of stay.

Respiratory disease w/ major chest operating room procedure, no major complication or comorbidity	75
Respiratory disease w/ major chest operating room procedure, minor complication or comorbidity	76
Respiratory disease w/ other respiratory system operating procedure,	
no complication or comorbidity	77
Respiratory infection w/ minor complication, age greater than 17	79
Respiratory infection w/ no minor complication, age greater than 17	80
Simple Pneumonia w/ minor complication, age greater than 17	89
Simple Pneumonia w/ no minor complication, age greater than 17	90
Respiratory disease w/ ventilator support	475
Respiratory disease w/ major chest operating room procedure and	
major complication or comorbidity	538
Respiratory disease, other respiratory system operating procedure	

Diagnosis-related group codes assigned to cases of bacterial pneumonia

Common Issues → **Terminologies** / **Coding Systems** → **CPT**

 The American Medical Association developed the Current Procedural Terminology (CPT) in 1966 to provide a precoordinated coding scheme for diagnostic and therapeutic procedures that has since been adopted in the United States for billing and reimbursement.

CPT	CPT Description	Place of Service	POS Code
90801	Initial Diagnostic Interview	All	All
90804, 90806, 90808	Individual Psychotherapy	11 13	Office Assisted Living Facility
90816, 90818, 90822	Individual Psychotherapy	21 31 51 52	Inpatient hospital Skilled Nursing Facility Inpatient psychiatric facility Partial psychiatric facility
96101 96118	Psychological Testing Neuorpsychological Testing	All	All

Sample CPT codes used for physician procedure reporting

Common Issues → **Terminologies** / **Coding Systems** → **SNOMED**

 The College of American Pathologists developed Systematized Nomenclature of Medicine (SNOMED) as a multiaxial system for describing pathologic findings through postcoordination of topographic (anatomic), morphologic, etiologic, and functional terms.

Subacute onset Acute onset Insidious onset Sudden onset Severity: Severities Episodicity: Episodicities Course: Courses Descriptions: Bacterial pneumonia (disorder) Bacterial pneumonia Legacy codes: **SNOMED: DE-10100** CTV3ID: X100H

Concept: Bacterial pneumonia Concept Status Current Fully defined by ... Is a Infectious disease of lung Inflammatory disorder of lower respiratory tract Infective pneumonia Inflammation of specific body organs Inflammation of specific body systems Bacterial infectious disease Causative agent: Bacterium Pathological process: Infectious disease Associated morphology: Inflammation Finding site: Lung structure Onset:

Description-logic representation of the SNOMED-CT term "Bacterial pneumonia."

Common Issues → **Terminologies** / **Coding Systems** → **LOINC**

 Originally called Laboratory Observations, Identifiers, Names and Codes (LOINC), the system has been extended to include non-laboratory observations (vital signs, electrocardiograms), so Logical has replaced Laboratory to reflect the change.

Blood glucose	GLUCOSE:MCNC:PT:BLD:QN:		
Plasma glucose	GLUCOSE:MCNC:PT:PLAS:QN:		
Serum glucose	GLUCOSE:MCNC:PT:SER:QN:		
Urine glucose concentration	GLUCOSE:MCNC:PT:UR:QN:		
Urine glucose by dip stick	GLUCOSE:MCNC:PT:UR:SQ:TEST STRIP		
Glucose tolerance test at	GLUCOSE ² H POST 100 G GLUCOSE PO:		
2 hours	MCNC:PT:PLAS:QN:		
Ionized whole blood calcium	CALCIUM.FREE:SCNC:PT:BLD:QN:		
Serum or plasma ionized calcium	CALCIUM.FREE:SCNC:PT:SER/PLAS:QN:		
24-hour calcium excretion	CALCIUM.TOTAL:MRAT:24H:UR:QN:		
Whole blood total calcium	CALCIUM.TOTAL:SCNC:PT:BLD:QN:		
Serum or plasma total calcium	CALCIUM.TOTAL:SCNC:PT:SER/PLAS:QN:		
Automated hematocrit	HEMATOCRIT:NFR:PT:BLD:QN: AUTOMATED COUNT		
Manual spun hematocrit	HEMATOCRIT:NFR:PT:BLD:QN:SPUN		
Urine erythrocyte casts	ERYTHROCYTE CASTS:ACNC:PT:URNS:SQ: MICROSCOPY.LIGHT		
Erythrocyte MCHC	ERYTHROCYTE MEAN CORPUSCULAR HEMOGLOBIN		
	CONCENTRATION:MCNC:PT:RBC:QN:AUTOMATED COUNT		
Erythrocyte MCH	ERYTHROCYTE MEAN CORPUSCULAR HEMOGLOBIN:MCNC:PT:RBC:QN: AUTOMATED COUNT		
LOINC Code examples			

Common Issues → **Terminologies** / **Coding Systems** → **RxNorm** / **NDC**

- The WHO Drug Dictionary is an international classification of drugs that provides proprietary drug names used in different countries.
- Drugs are classified according to the Anatomical-Therapeutic-Chemical (ATC) classification, with cross-references to manufacturers and reference sources.
- The National Drug Codes (NDC), produced by the FDA, is applied to all drug packages.
- RxNorm is the results of a collaboration between the FDA, the NLM, the VA, and the pharmacy knowledge base vendors.

Category	Property	Value	
NAMES	RxNorm Name	venlafaxine 100 MG Oral Tablet [Effexor]	
	RxNorm Synonym	Effexor 100 MG Oral Tablet	
	RxNorm Synonym	Effexor 100 MG (as venlafaxine hydrochloride) Oral Tablet	
CODES	RxCUI	208848	
	UMLSCUI	C0710468	
	NDA	NDA020151	
	SPL SET ID	cf2d9bee-f8e3-477a-e4b4-f0e82657b7d2	
ATTRIBUTES	ТТΥ	SBD	
	HUMAN_DRUG	US	
	PRESCRIBABLE	Y	
	AVAILABLE_STRENGTH	100 MG	
SOURCES	Source	Gold Standard Alchemy	
	Source	Multum MediSource Lexicon	
	Source	Micromedex RED BOOK	
	Source	Metathesaurus FDA National Drug Code Directory	
	Source	Metathesaurus FDA Structured Product Labels	

Common Issues → **Terminologies** / **Coding Systems** → **UMLS**

- In 1986, the NLM, began consulting contractors to identify ways to construct a resource that would bring together and disseminate controlled medical terminologies. The Unified Medical Language System has been updated annually since then.
- Its principal component is the Metathesaurus, which contains over one million terms collected from over 100 different sources (including many of those that we have discussed), and attempts to relate synonymous and similar terms from across the different sources.

	C0004626	Pneumonia Bacterial
	C0023241	Legionnaires' Disease
	C0032286	Pneumonia due to other specified bacteria
	C0032308	Pneumonia Stanbylococcal
	C0152489	Salmonella pneumonia
	C0155858:	Other bacterial pneumonia
	C0155859	Pneumonia due to Klebsiella pneumoniae
	C0155860	Pneumonia due to Pseudomonas
	C0155862	Pneumonia due to Streptococcus
	C0155865:	Pneumonia in pertussis
	C0155866	Pneumonia in anthrax
	C0238380	PNEUMONIA KI EBSIELLA AND OTHEB GRAM NEGATIVE BACILLI
	C0238381:	PNEUMONIA, TULAREMIC
	C0242056:	PNEUMONIA, CLASSIC PNEUMOCOCCAL LOBAR
	C0242057:	PNEUMONIA, FRIEDLAENDER BACILLUS
	C0275977:	Pneumonia in typhoid fever
	C0276026:	Hemophilus influenzae pneumonia
	C0276039:	Pittsburgh pneumonia
	C0276071:	Achromobacter pneumonia
	C0276080:	Pneumonia due to Proteus mirabilis
	C0276089:	Pneumonia due to Escherichia coli
	C0276523:	AIDS with bacterial pneumonia
	C0276524:	AIDS with pneumococcal pneumonia
	C0339946:	Pneumonia with tularemia
	C0339947:	Pneumonia with anthrax
	C0339952:	Secondary bacterial pneumonia
1		

Some of the bacterial pneumonia concepts in the UMLS Metathesaurus

Common Issues → Terminologies / Coding Systems → UMLS (cont.)

Bacterial pneumonia			
Source:	CSP93/PT/2596-5280; DOR27/DT/U000523; ICD91/PT/482.9; ICD91/IT/482.9		
Parent: Child:	Bacterial Infections; Pneumonia; Influenza with Pneumonia Pneumonia, Mycoplasma		
Narrower:	Pneumonia, Lobar; Pneumonia, Rickettsial; Pneumonia, Staphylococcal; Pneumonia due to <i>Klebsiella pneumoniae;</i> Pneumonia due to Pseudomonas; Pneumonia due to <i>Hemophilus</i> <i>influenzae</i>		
Other:	Klebsiella pneumoniae, Streptococcus pneumoniae		
Pneumonia, Lo	bar		
Source:	ICD91/IT/481; MSH94/PM/D011018; MSH94/MH/D011018; SNM2/RT/M-40000; ICD91/PT/481; SNM2/PT/D-0164; DXP92/PT/U000473; MSH94/EP/D011018; INS94/MH/D011018;INS94/SY/D011018		
Synonym:	Pneumonia, diplococcal		
Parent:	Bacterial Infections; Influenza with Pneumonia		
Broader:	Bacterial Pneumonia; Inflammation		
Semantic:	inverse is a: Pneumonia		
Gemanne.	has-result: Pneumococcal Infections		
Pneumonia, St	aphylococcal		
Source:	ICD91/PT/482.4; ICD91/IT/482.4; MSH94/MH/D011023; MSH94/PM/D011023; MSH94/EP/D011023; SNM2/PT/D-017X; INS94/MH/D011023; INS94/SY/D011023		
Parent:	Bacterial Infections; Influenza with Pneumonia		
Broader:	Bacterial Pneumonia		
Semantic	inverse-is-a: Pneumonia; Staphylococcal Infections		

Some of the information available in the UMLS about selected pneumonia concepts.

Common Issues \rightarrow **Standards of Info Exchange** \rightarrow **HL7**

- The purpose of a data-interchange standard is to permit one system, the sender, to transmit to another system, the receiver, all the data required to accomplish a specific communication, or transaction set, in a precise, unambiguous fashion.
- Open Systems Interconnection (OSI) reference model: describes seven levels of requirements or specifications for a communications exchange: physical, data link, network, transport, session, presentation, and application.
- Level 7, the application level, deals primarily with the semantics or data-content specification of the transaction set or message → reflected in HL7 name.
- HL7 is the most widely implemented health care data-messaging standard and is in use at over 1,500 health care facilities.
- Version 1.0: served mainly to define the scope and format of standards.
- Version 2.0: was the basis for several data-interchange demonstrations involving more than 10 vendors.
- Version 2.2: it was approved by ANSI as the first health care data-interchange American National Standard.
- Version 3.0: is object oriented and based on a Reference Information Model (RIM).

Common Issues → Standards of Info Exchange → HL7 (cont.)

MSH|^~&\|DHIS|OR|TMR|SICU|199212071425|password|ADT|16603529|P|2.1<cr>

EVN|A02|199212071425||<cr>

PID|||Z99999^5^M11||GUNCH^MODINE^SUE|RILEY|19430704 |F||C|RT. 1, BOX 97^ZIRCONIA^NC^27401 |HEND|(704)982-1234|(704)983-1822||S|C||245-33-9999<cr>

PV1|1|I|N22^2204|||OR^03|0940^DOCTOR^HOSPITAL^A||| SUR|||||A3<cr>

OBR|7|||93000^EKG REPORT|R|199401111000|199401111330|||RMT||||19940111 11330|?|P030||||||199401120930|||||88-126666|A111|VIRANYI^ANDREW<cr>

OBX|1|ST|93000.1^{VENTRICULAR RATE(EKG)||91|/MIN|60-100<cr>}

OBX|2|ST|93000.2^ATRIAL RATE(EKG)||150|/MIN|60-100<cr>

• • •

OBX|8|ST|93000&IMP^EKG DIAGNOSIS|1|^ATRIAL FIBRILATION<cr>

An example of an HL7 v2.3 ADT transaction message. This message includes the Message Heading segment, the EVN trigger definition segment, the PID patient-identification segment, the PV1 patient-visit segment, the OBR general-order segment, and several OBX results segments.

Common Issues → Standards of Info Exchange → HL7 (cont.)

```
Code="DRIV">
t classCode="ACT" moodCode="EVN">
    <templateId root="2.16.840.1.113883.10.20.22.4.30"/>
    <!-- ** Allergy problem act ** -->
    <id root="36e3e930-7b14-11db-9fe1-0800200c9a66"/>
    <code code="48765-2" codeSystem="2.16.840.1.113883.6.1
                                                             codeSystemName="LOINC"
                                                                                    tisplayName="Allergies, adverse reactions, aler
    <statusCode code="active"/>
    <effectiveTime value="20090909">
             <low value="20090902"/>
             <high value="20100103"/>
    </effectiveTime>
    <entryRelationship typeCode="SUB]">
             <observation classCode="OBS" moodCode="EVN">
                     <!-- allergy observation template -->
                     <templateId root="2.16.840.1.113883.10.20.22.4.7"/>
                     <id root="4adc1020-7b14-11db-9fe1-0800200c9a66"/>
                     <code code="416098002" displayName="drug allergy" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMED C
                     <statusCode code="completed"/>
                     <effectiveTime>
                             <low value="20110215"/>
                     </effectiveTime>
                     <value xsi:type="CD" code="282100009" displayName="Adverse reaction to substance" codeSystem="2.16.840.1.11388</pre>
                             <originalText>
                                     <reference value="#reaction2"/>
                             </originalText>
                     </value>
                     <participant typeCode="CSM">
                             <participantRole classCode="MANU">
                                     <playingEntity classCode="MMAT">
                                             <code code="Q830PW7520" displayName="Codeine" codeSystem="2.16.840.1.113883.4.9" codeS
                                                     <originalText>
                                                             <reference value="#reaction3"/>
                                                     </originalText>
                                             </code>
                                             <name>Aspirin</name>
                                     </playingEntity>
                             </participantRole>
                     </participant>
                     <entryRelationship typeCode="SUBJ">
                             <observation classCode="OBS" moodCode="EVN">
                                     <templateId root="2.16.840.1.113883.10.20.22.4.28"/>
```

An example of an HL7 v3 CCDA (Consolidated Clinical Doc Architecture) formatted discharge summary.

Common Issues \rightarrow **Standards of Info Exchange** \rightarrow **Others**

- Digital Imaging and Communications in Medicine (DICOM): The purposes of the ACR/NEMA standard were to promote a generic digital-image communication format, to facilitate the development and expansion of picture-archiving and communication systems.
- **ASTM E1238**: Standard Specification for Transferring Clinical Observations Between Independent Systems used in commercial and reference clinical laboratories.
- IEEE 1073: Standard for Medical Device Communications, has produced a family of documents that defines the entire seven-layer communications requirements for the Medical Information Bus (MIB)/
- ASC X12, an independent organization accredited by ANSI, has developed message standards for purchase-order data, invoice data, and other commonly used business documents.
- UCC is an ANSI-approved organization that defines the universal product code. Standards include specifications for the printing of machine-readable representations (bar codes).
- **The National Council for Prescription Drug Programs (NCPDP)**: have created a set of standards to communicate medication orders and other Rx related issues.

Common Issues → **Usability Issues** / **Human Factors**

- **Usability** is defined as:
 - <u>Learnability</u>: system should be relatively easy to learn
 - <u>Efficiency</u>: an experienced user can attain a high level of productivity
 - <u>Memorability</u>: system features should be easy to retain once learned
 - <u>Errors</u>: system should be designed to minimize errors and support error detection
 - <u>Satisfaction</u>: the user experience should be subjectively satisfying
- Heuristic evaluation is a usability inspection method, in which the system is evaluated on the basis of a small set of well-tested design principles. This methodology embodies a particular philosophy, which emphasizes simplicity and functionality over intricacy of design and presentation.
- Human Computer Interaction (HCI) is a multifaceted discipline devoted to the study and practice of usability. HCI has emerged as a central area of both computer science research and development and applied behavioral and social science.
- Cognitive walkthrough (CW) is a cognitive task-analytic method that has been applied to the study of usability and learnability of several distinct medical information technologies. The method involves identifying sequences of actions and goals needed to accomplish a given task.


Common Issues → **Usability Issues** / **Human Factors** (cont.)



EHR navigation with no feedback on completed steps

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Common Issues \rightarrow Value-Added



Academic and other publications on HIT value-added (mainly cost) are available but impact on other triple aims (clinical outcomes) are still missing rigor scientific evidence...



Additional Resources

Resources – Books



Title	Guide to Health Informatics
Authors	Coiera, E
Year	2003
Hardcover	472 pages
Publisher	Hodder Arnold Publication
Language	English
ISBN	0340764252

Resources – Books (cont.)



Title	Biomedical Informatics: Computer Applications in HealthCare and Biomedicine
Authors	Shortliffe, E.H. and Cimino, J.J (eds)
Year	2014
Hardcover	1024 pages
Publisher	Springer; 4 th edition (2014)
Language	English
ISBN	978-1-4471-4474-8
Link	http://www.springer.com/us/book/9781447144731

Resources – Web

Associations:

- AMIA (American Medical Information Association): www.amia.org
- IMIA (International Medical Information Association): www.imia-medinfo.org
- HIMSS (Healthcare Information and Management Systems Society): www.himss.org
- Academy Health (HIT Interest Group): www.academyhealth.org

Government and Non-for-profit:

- ONC: www.healthit.gov
- CMS MU: www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms
- HL7: hl7.org
- NLM: https://www.nlm.nih.gov

Journals:

- JAMIA (Journal of AMIA): jamia.bmj.com
- JMIR (Journal of Medical Internet Research): www.jmir.org
- IJMI (International Journal of Medical Informatics): www.ijmijournal.com
- HIJ (Health Informatics Journal): jhi.sagepub.com
- ACI (Applied Clinical Informatics): aci.schattauer.de

Resources – Web (cont.)



Summary

- US Healthcare
 - General, Cost, Triple Aims
- Biomedical / Health Informatics
 - Concept & Definition
 - History
 - Subdomains
 - Data Sources (EHR, claims...)
 - Systems (provider, payers, patients, public/government)
 - Methods (logic, probability, expert system, NN, GA, DM, IR/NLP, BD)
- Use Cases (population health examples)
 - Clinical
 - Consumer
 - Community / Population / Public

Drivers

- Incentives (MU, HIE, Beacon)
- Mandates (ACA-P4P: PCMH, ACO)
- Facilitators (ONC, S&I)
- Common Issues
 - Terminologies (ICD, SNOMED, RxNorm, LOINC, ...)
 - Standards of Information Exchange (HL7, DICOM)
 - Usability Issues / Human Factors
 - Value-Added
- Resources
 - Books
 - Web (Associations, Government, Non-profit)