

Introduction to Clinical Informatics

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About Me

- **About the instructor:**

- Jake Luo, PhD, Associate Professor
Department of Health Informatics and Administration
- Director of Center for Health System Solutions
LinkedIn: <https://www.linkedin.com/in/jakeluo/>
- Lab research deals with massive amount of data: patient records, clinical trials, social media, FDA drugs data, consumer comments; leveraging the data to find new knowledge to advance medicine and health care

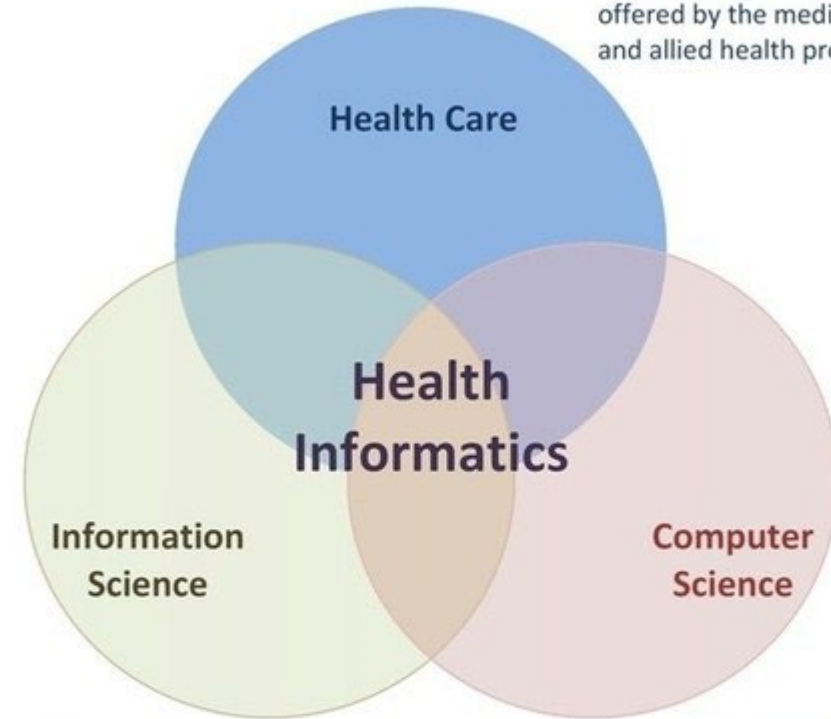
- **Book:** Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics)

- **Overall goal of this class?**

- Introduce clinical informatics
- Cover major biomedical data types and common standards
- Discuss common functions of electronic health record (EHR) systems
- Describe clinical decision support systems

Health/Clinical Informatics

- Health Informatics is a cross-disciplinary field that lies in the intersection of information science, computer science, and health care



The prevention, treatment and management of illness and the promotion of health and well-being through the services offered by the medical, nursing and allied health professions

The collection, classification, manipulation, storage, retrieval and dissemination of information;
The application and use of knowledge;
The interaction between people, organisations and information systems.

The theoretical foundations of information and computation together with their implementation and application in computer systems

Why We Need Informatics?

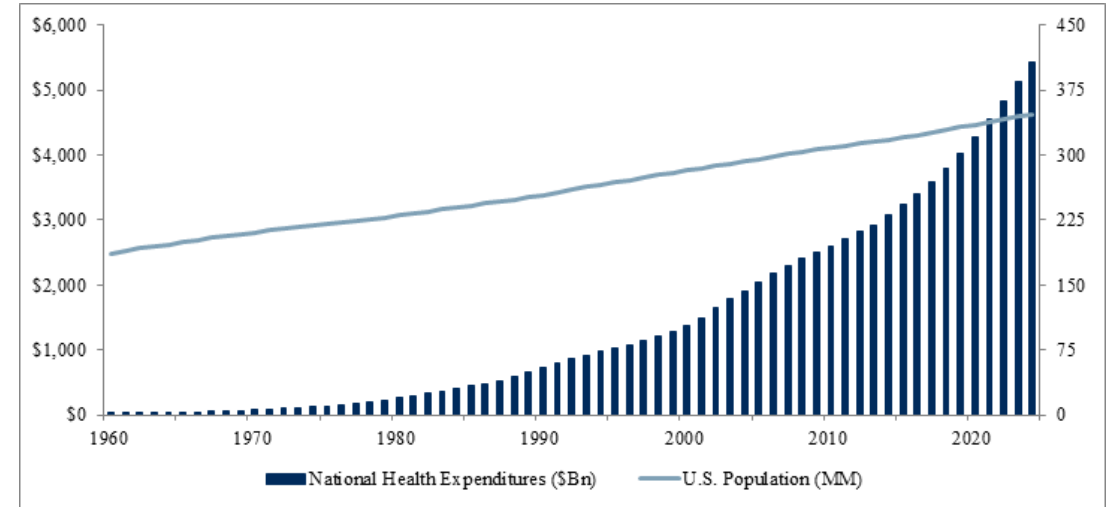
- Healthcare is very complex: complex business, multidisciplinary, diverse service population, happening on many levels on a person and in our society
- Informatics provides systematic information strategies and solutions to support the healthcare system
- Better information leads to better decisions
- Better information system leads to better management and collaboration
- Health services, health business management, governing and policy making all needs good information system



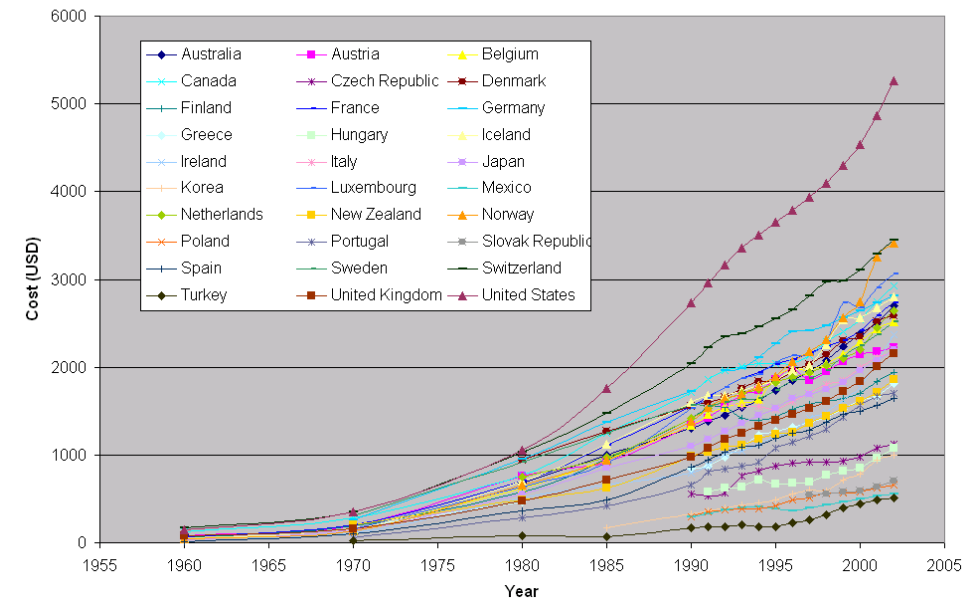
Significant Growth of Healthcare Cost

- Growing population size
- Aging
- Shortage of labor

- Healthcare Informatics is a key strategy to reduce health care cost and improve health outcome
 - Improve efficiency
 - Share information and knowledge
 - Encourage patient participation
 - Increase coordination between departments
 - Improve health outcome



per capita health expenditure



Who Involves in Health Informatics (stakeholders)

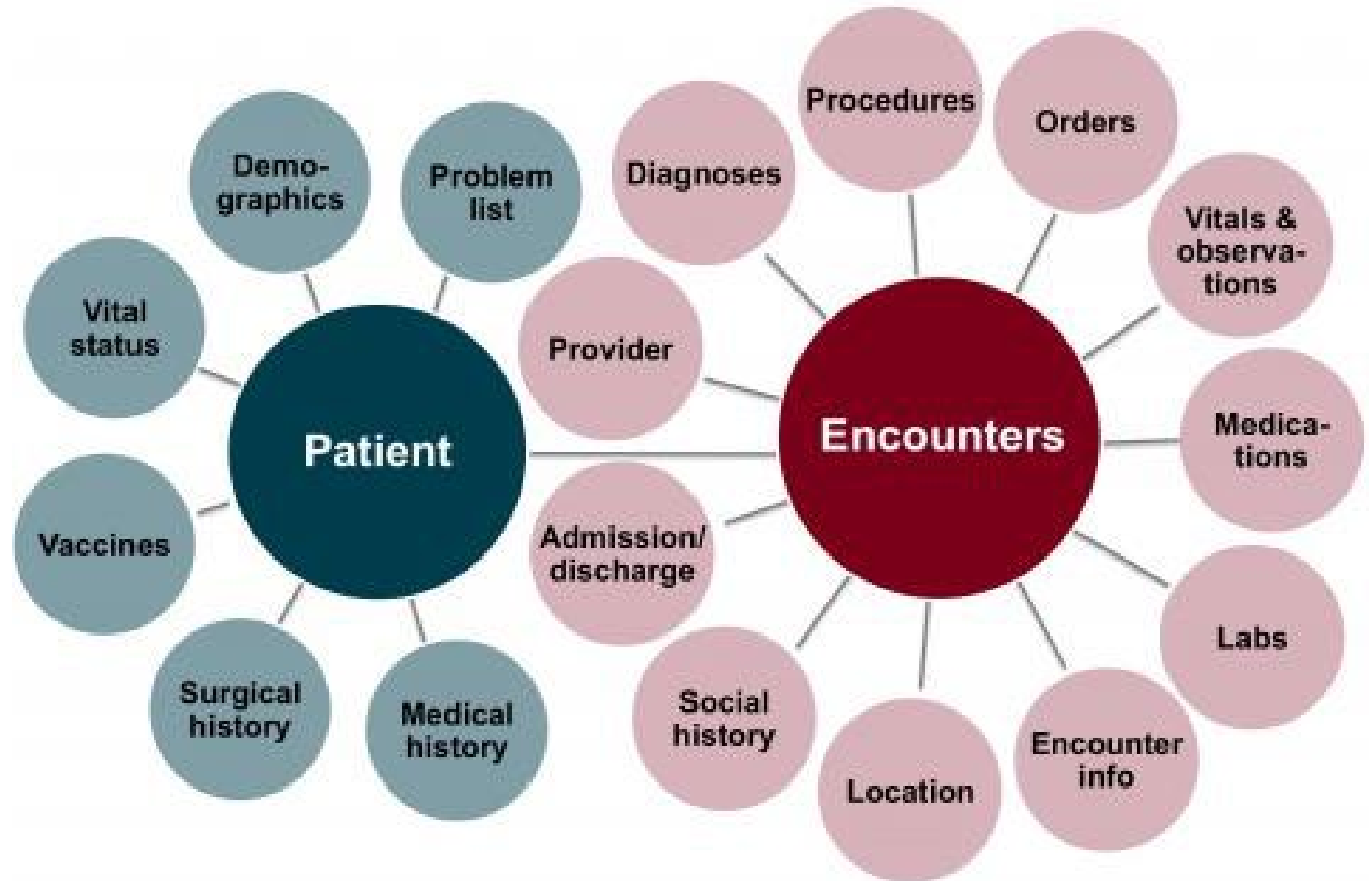
- Health professionals
 - Doctors (Primary / secondary care)
 - Nurses
 - Allied professions
- Healthcare Administrators
- Government and policy makers
- Biomedical Researchers
- Pharmaceutical Companies
- IT professionals
- Patients



Clinical Data

Clinical Data

- Clinical data are central to health care, because they focus on patients. They are critical to the process of clinical decision making
- All modern health care encounter activities involve gathering, analyzing, or using data.



Who collects data

- Data collection team: physician, nurse, administrator, staff, lab technician, radiologist, pharmacists, patients
- Nowadays, a lot of the data are also generated by technologies, such as vital sign sensors, wearable devices, voice-to-text summary machines



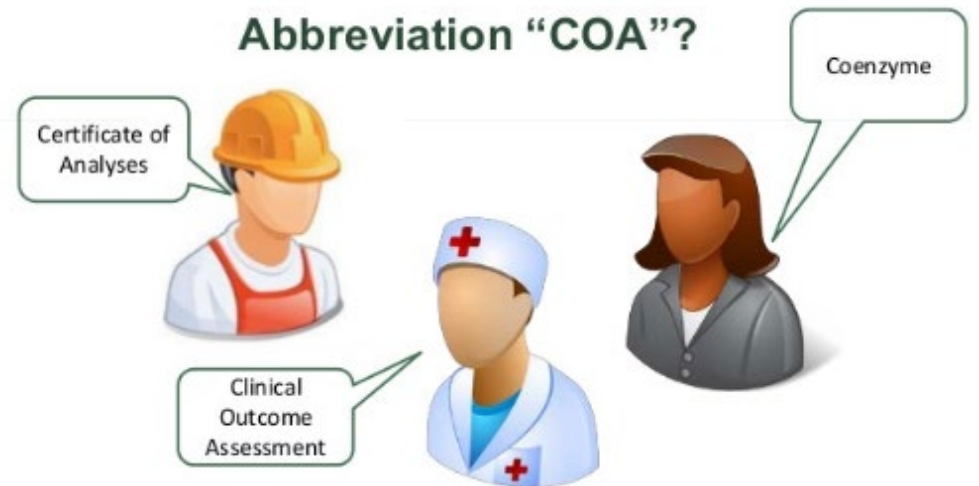
Health data usage scenarios

- Aggregation use: public health, clinical research (P45)
- Used as history of patient records (P46)
- Support communication (Fig 2.5, 2.6)
- Anticipate future problem (P48)
- Prevention measure (P48)
- Identify outliers (P49, Fig 2.7)
- Clinical research (P50)
 - Randomized Clinical Trials
 - Retrospective Studies



Structure of clinical data

- Standardized controlled vocabulary (coding systems)
 - A lack of formal definition of medical terms
 - A lack of vocabulary standards
- Clinical Ontology
 - Clinical entities, such as disease names, lab test items, procedure names, drug names etc
 - Relationships of clinical entities, such as drug -> treat - diseases



Diagnosis Coding System

- ICD: international classification of diseases
- SNOMED-CT: Systematized Nomenclature of Medicine – Clinical Terms



ICD code example

- Commonly used in billing, insurance reimbursement, classifying patients, patient population research

174.5: Malignant neoplasm of female breast, lower-outer quadrant	Three possible codes based on laterality: <ul style="list-style-type: none">• C50.511- Malignant neoplasm of lower-outer quadrant of right female breast• C50.512- Malignant neoplasm of lower-outer quadrant of left female breast• C50.519- Malignant neoplasm of lower-outer quadrant of unspecified female breast
174.6: Malignant neoplasm of female breast, axillary tail	Three possible codes based on laterality: <ul style="list-style-type: none">• C50.611- Malignant neoplasm of axillary tail of right female breast• C50.612- Malignant neoplasm of axillary tail of left female breast• C50.619- Malignant neoplasm of axillary tail of unspecified female breast
174.8: Malignant neoplasm of female breast, other specified sites of female breast	Three possible codes based on laterality: <ul style="list-style-type: none">• C50.811- Malignant neoplasm of overlapping sites of right female breast• C50.812- Malignant neoplasm of overlapping sites of left female breast• C50.819- Malignant neoplasm of overlapping sites of unspecified female breast
174.9: Malignant neoplasm of female breast, unspecified	Three possible codes based on laterality: <ul style="list-style-type: none">• C50.911- Malignant neoplasm of unspecified site of right female breast• C50.912- Malignant neoplasm of unspecified site of left female breast• C50.919- Malignant neoplasm of unspecified of unspecified female breast

CPT (Current Procedural Terms)

- First published by American Medical Association in 1966
- Commonly used in billing and reimbursement
- CPT-4 is the most widely accepted in use for reporting physician procedures for insurance reimbursement
- Link: <https://www.ama-assn.org/practice-management/cpt-current-procedural-terminology>

LOINC (logical observation identifiers names and codes)

- For encoding lab test, lab test results, clinical observations

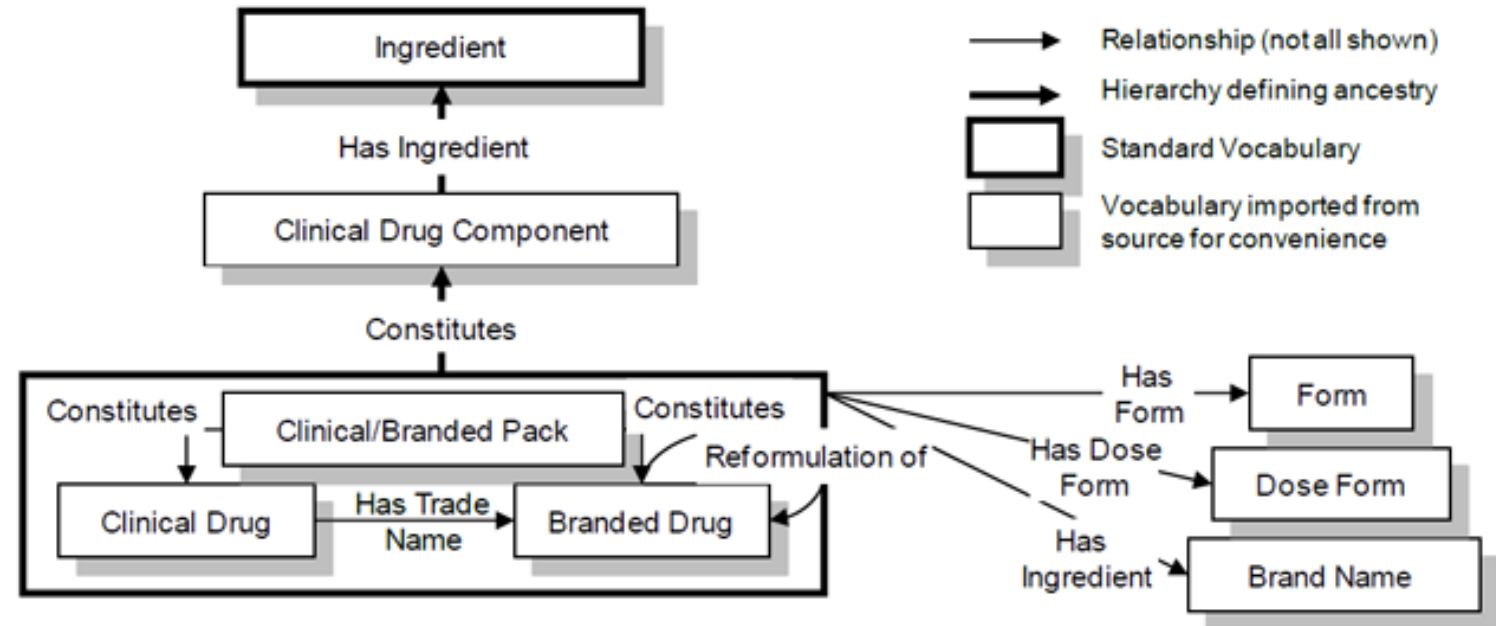
- Link:

<https://loinc.org/international/>

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 2 hours	GLUCOSE^2H POST 100 G GLUCOSE PO: 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
Erythrocyte MCV	ERYTHROCYTE MEAN CORPUSCULAR VOLUME:ENTVOL:PT:RBC:QN:AUTOMATED COUNT
Automated Blood RBC	ERYTHROCYTES:NCNC:PT:BLD:QN: AUTOMATED COUNT
Manual blood RBC	ERYTHROCYTES:NCNC:PT:BLD:QN: MANUAL COUNT
ESR by Westergren method	ERYTHROCYTE SEDIMENTATION RATE:VEL:PT:BLD:QN:WESTERGREN
ESR by Wintrobe method	ERYTHROCYTE SEDIMENTATION RATE:VEL:PT:BLD:QN:WINTROBE


RxNORM






















- Collaboration result of NLM, FDA, and VA
- Specialized in drug terms
- Link: <https://www.nlm.nih.gov/research/umls/rxnorm/>





MeSH


- Medical Subject Heading (MeSH) is developed and maintained by NLM
- Primarily used to index and organize the topics of research publications
- <https://meshb.nlm.nih.gov/treeView>
- Demo: <https://www.ncbi.nlm.nih.gov/pubmed/29109303>


Anatomy [A] 


- Body Regions [A01] 
- Musculoskeletal System [A02] 
- Digestive System [A03] 
- Respiratory System [A04] 
- Urogenital System [A05] 
- Endocrine System [A06] 
- Cardiovascular System [A07] 
- Nervous System [A08] 
- Sense Organs [A09] 
- Tissues [A10] 
- Cells [A11] 
- Fluids and Secretions [A12] 
- Animal Structures [A13] 
- Stomatognathic System [A14] 
- Hemic and Immune Systems [A15] 
- Embryonic Structures [A16] 
- Integumentary System [A17] 
- Plant Structures [A18] 
- Fungal Structures [A19] 
- Bacterial Structures [A20] 
- Viral Structures [A21] 


Organisms [B] 


Diseases [C] 


Chemicals and Drugs [D] 


Analytical, Diagnostic and Therapeutic Techniques, and Equipment [E] 


Psychiatry and Psychology [F] 


Phenomena and Processes [G] 


Disciplines and Occupations [H] 


Anthropology, Education, Sociology, and Social Phenomena [I] 


Technology, Industry, and Agriculture [J] 


Humanities [K] 

Information Science [L] 

Named Groups [M] 

Health Care [N] 

Publication Characteristics [V] 

Geographicals [Z] 

RadLex

- Produced by Society of North America (RSNA)
- Used in the radiology domain for indexing and information retrieval
- Includes names of anatomic parts, radiology devices, exams, procedures etc.
- Link: <http://www.radlex.org/>

RadLex Tree Browser

Begin typing to search...

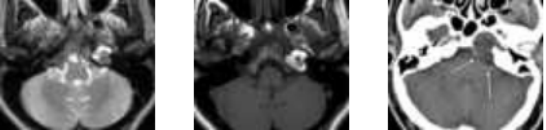
- Report
- Imaging observation
- Procedure step
- Process
- Radlex non-anatomical set
- Procedure
- Radlex descriptor
- Object
- Anatomical entity
- Report component
- Clinical finding
 - Incidental finding
 - Pathophysiologic finding
 - Symptom
 - Pain
 - Constipation
 - Shortness of breath
 - Fever
 - Dizziness
 - Cough
 - Proteinuria
 - Diarrhea
 - Headache
- Benign finding

- Temporal entity
- Imaging modality
- Property
- Non-anatomical substance

Headache

Preferred Name: Headache
RadLex ID: [RID39094](#)
PURL: <http://www.radlex.org/RID/RI>

Sample Images:



Radiology 2013 Radiology 2013 Radiology 2013

Image search powered by **ARRS GoldMiner®**

UMLS

- Unified medical language system (UMLS)
- Maintained by NLM and first published in 1989
- Probably the largest controlled medical terminology
- Metathesaurus 8.9 million terms from over 160 sources
- Link: <https://www.nlm.nih.gov/research/umls/>

The screenshot displays the UMLS web interface. At the top, there are navigation tabs: Search, Tree, Recent Searches, Basic View, Report View, and Raw View. The 'Search' tab is active, showing a search form with the following fields:

- Search Type: Word
- Release: 2017AB
- Source: All Sources (with a dropdown menu listing AIR, ALT, AOD, AOT)

 The search term 'diabetes' is entered in the search box. Below the search form, the 'Search Results (2568)' section shows a list of terms with their corresponding UMLS IDs, such as C0011847 Diabetes, C0011849 Diabetes Mellitus, and C0011860 Diabetes Mellitus, Non-Insulin-Dependent.

On the right side, the 'Basic View' for the selected concept [C0011847] Diabetes is shown. It includes:

- Semantic Types:** Disease or Syndrome [T047]
- Atoms (8):** A list of related terms with their IDs, such as diabetes NOS [A17850799/ICD10CM/ET/E11], Diabetes [A23873288/LCH_NW/PT/sh85037456], etc.
- Contexts (5):** Contextual relationships like OMIM/PTCS/Diabetes (1), PSY/PT/Diabetes (2), etc.
- Concept Relations (14):** A list of relationships between concepts, such as RO | MTH | Arthropathy associated with an endocrine AND/OR me, RO | MTH | Glyburide | C0017628, etc.

Data Interchange Standards: HL7

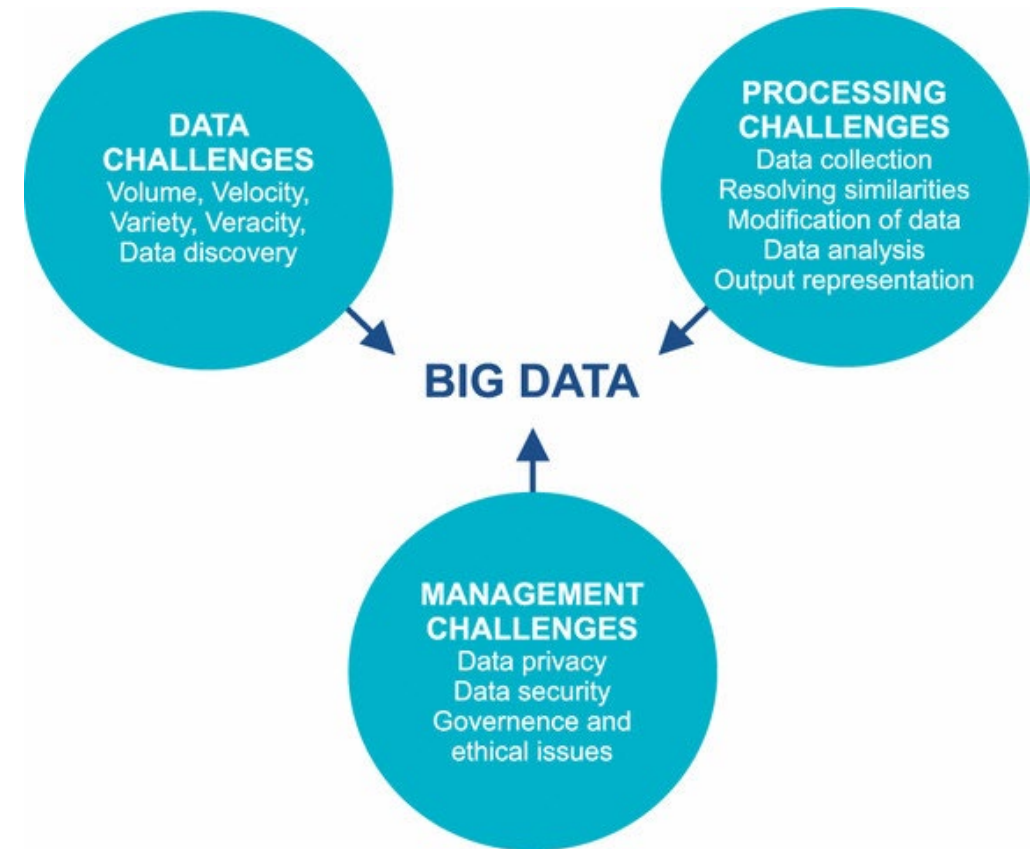
- Version 1.0 was published in 1987.
- HL7 is a messaging data interchange protocol
- Link: <http://www.hl7.org/>

Fig. 7.15 An example of an HL7 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

```
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||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>
```

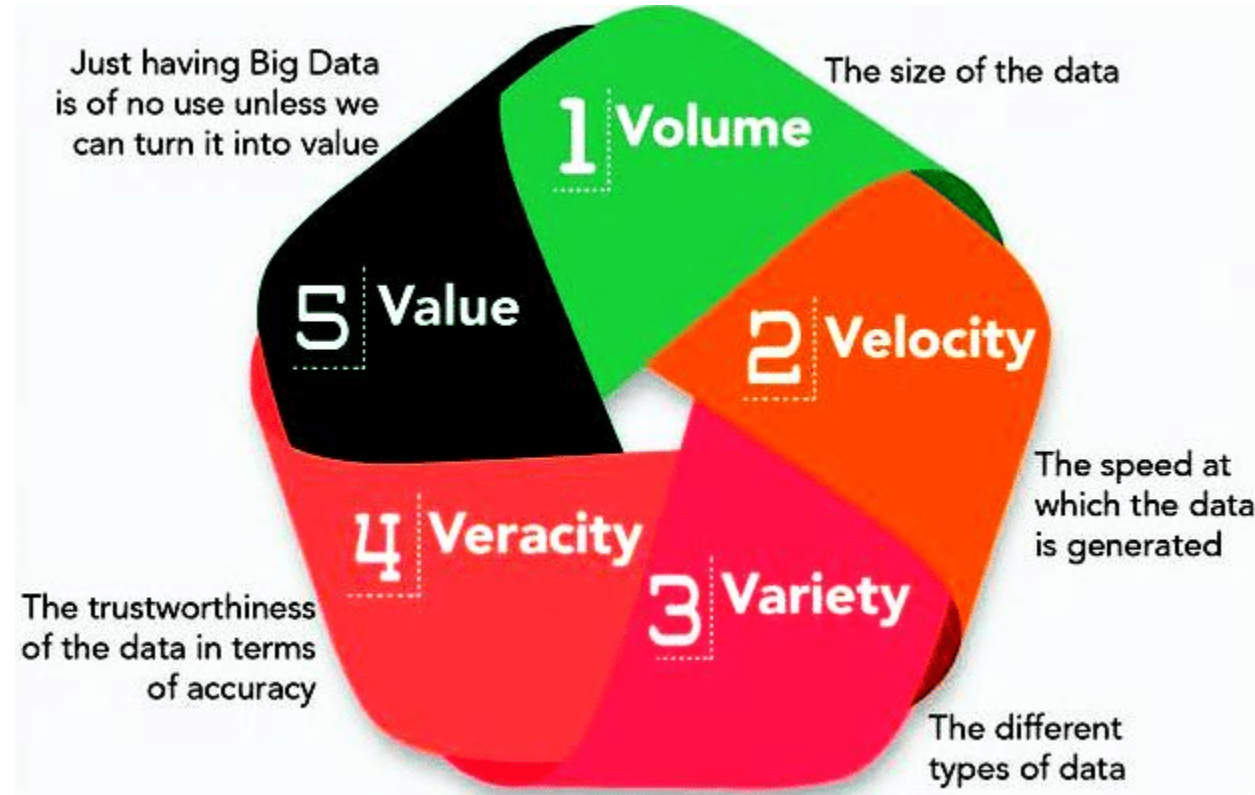
New Data Challenges

- Omic data
- Biomedical Data, translational data
- Aggregated clinical research
- Public health data
- The “big data” problem



The rise of “big” clinical data

- More and more clinical and biomedical data are collected in the past 20 years, such as EHRs, genomics, large-scale surveys, clinical trials
- Very valuable for knowledge discovery and advancing medical science
- Can be used to create new applications
- How to process and leverage the data for research and application development becomes a hot topic
- “Health Data Science”
- Five “V”

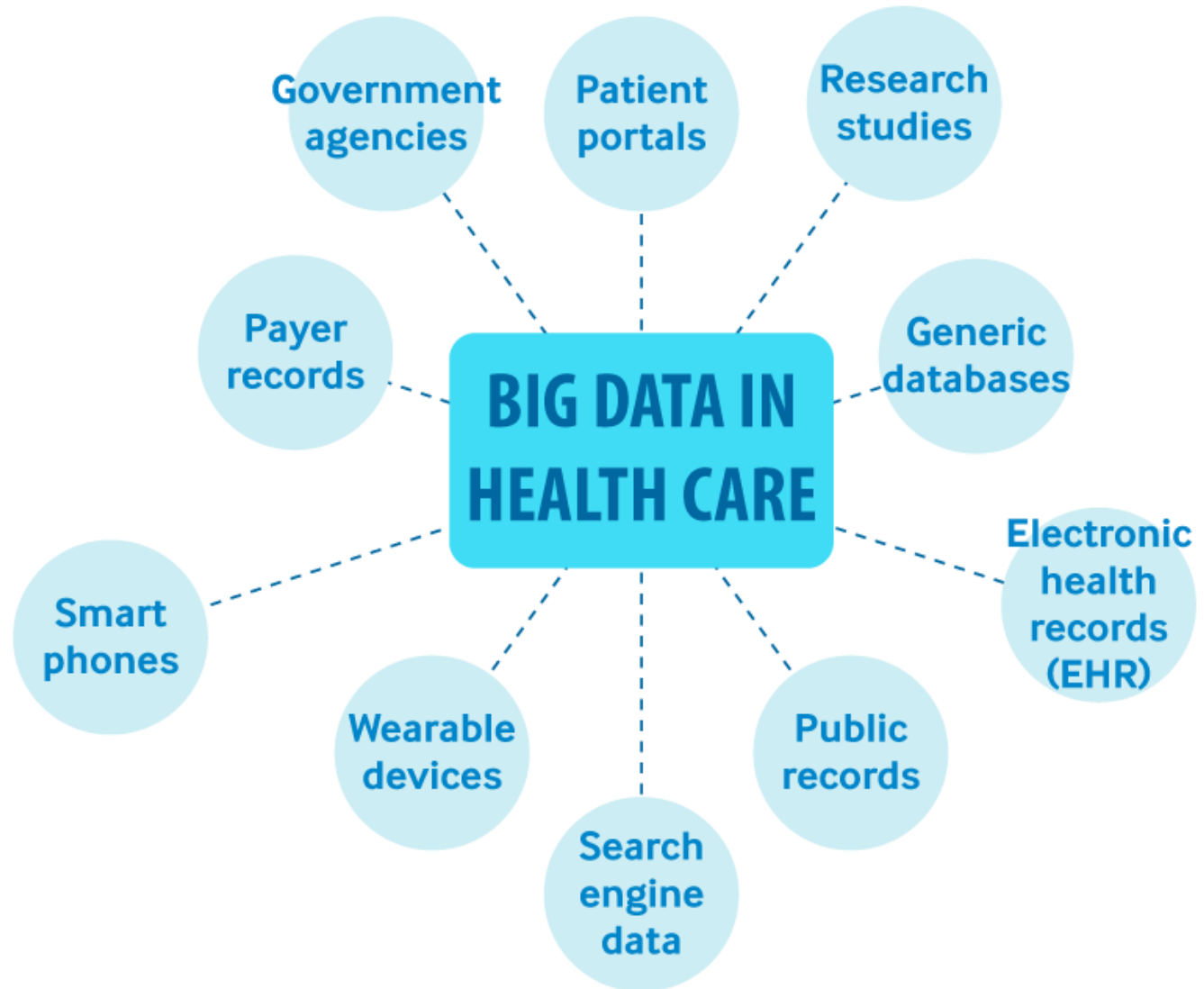


Sources of Big Data in Health Care

Big Data

- NEJM Article:

Healthcare
Big Data and
the Promise
of Value-
Based Care



Applications for Big Data in Healthcare



Diagnostics

Data mining and analysis to identify causes of illness



Preventative medicine

Predictive analytics and data analysis of genetic, lifestyle, and social circumstances to prevent disease



Precision medicine

Leveraging aggregate data to drive hyper-personalized care



Medical research

Data-driven medical and pharmacological research to cure disease and discover new treatments and medicines



Reduction of adverse medication events

Harnessing of big data to spot medication errors and flag potential adverse reactions



Cost reduction

Identification of value that drives better patient outcomes for longterm savings



Population health

Monitor big data to identify disease trends and health strategies based on demographics, geography, and socio-economics

Reading Materials

- Clinical Informatics, clinical data, and common clinical data standards
 - a. Recent advances of HCI in decision-making tasks for optimized clinical workflows and precision medicine.
 - b. Healthcare Big Data and the Promise of Value-Based Care.

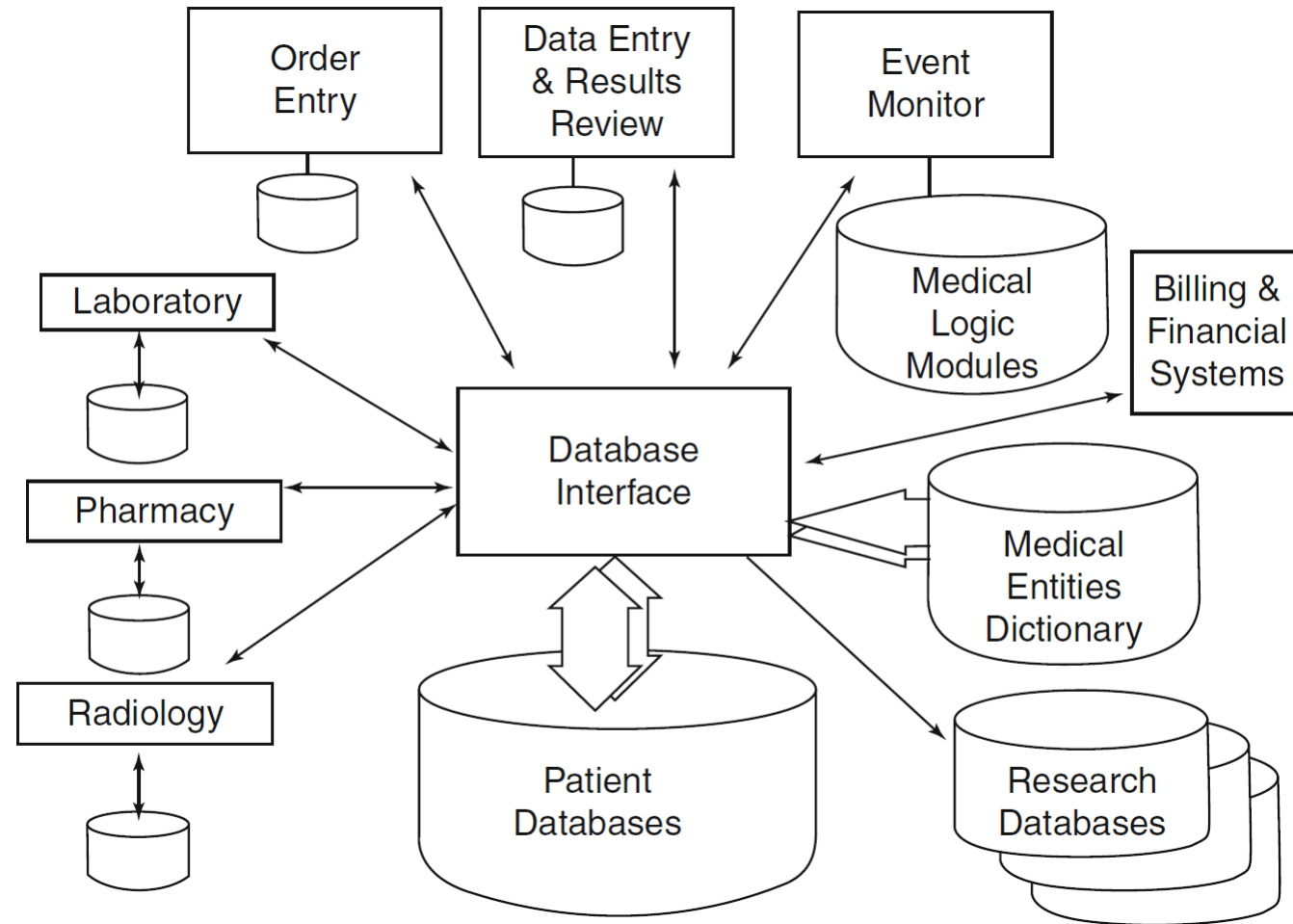
Electronic Health Record System (EHRs)

EHR: Electronic Patient Records

- An **electronic health record (EHR)** is a repository of electronically maintained information about an individual's health status and health care, stored such that it can serve the multiple legitimate uses and users of the record.
- The term **electronic health record system** (also referred to as a computer-based patient record system) includes the active tools that are used to manage the information, but in common use, the term EHR can refer to the entire system.

EHR: Data Perspective (P396)

- Fig 12.1



EHR Components – Integrated View

• Fig 12.1

The screenshot displays an integrated EHR view for patient MAURER, ALFRED. The interface includes a patient information header, a navigation pane on the left, a central data table, a report viewer, and several image thumbnails.

Available Reports:

- Clinical Reports
- Health Summary
- HDR Reports
- Dept. of Defense Reports
- Imaging (local only)
- Graphing (local only)
- Lab Status
- Blood Bank Report
- Anatomic Path Reports
- Dietetics Profile
- Nutritional Assessment
- Vitals Cumulative
- Procedures (local only)
- Daily Order Summary
- Order Summary for a Date Range
- Chart Copy Summary
- Outpatient RX Profile
- Med Admin Log (BCMA)
- Med Admin History (BCMA)
- Surgery (local only)
- Event Capture

Imaging (local only) [From: Mar 10, 1997 to Mar 17, 2009] Max/site: 10

Procedure Date/Time	Procedure Name	Report S.	Exam Status	Case #	[+]
03/17/2009 15:00	CHEST 2 VIEWS PA&LAT	No Report	Examined	56	[+]
02/23/2009 09:00	CHEST SINGLE VIEW	Verified	Complete	52	[+]
02/18/2009 11:00	CHEST SINGLE VIEW	Verified	Complete	51	[+]
02/15/2009 16:00	CHEST 2 VIEWS PA&LAT	Verified	Complete	53	[+]
02/04/2009 07:00	CHEST 2 VIEWS PA&LAT	Verified	Complete	55	[+]
02/03/2009 08:00	CT HEAD W/O CONT	No Report	Examined	40	[+]
12/24/2008 16:30	CT HEAD W/O CONT	Verified	Complete	39	[+]

Report:
Postsurgical changes of the mediastinum are stable. The heart size and vascularity are normal and there are no effusions. There are multiple pleural plaques, which are unchanged. There are no acute infiltrates. Bones and soft tissues are unremarkable.

Impression:
No acute findings.

Primary Diagnostic Code: MINOR ABNORMALITY

Primary Interpreting Staff:
ONE PROVIDER, IMAGING GUY (Verifier)

Navigation: Cover Sheet | Problems | Meds | Orders | Notes | Consults | DIC Summ | Labs | Reports

Image Thumbnails (Left):

- Group of 2: CHEST 2 VIEWS PA&LAT
- Group of 2: CHEST 2 VIEWS PA&LAT
- Group of 165: CT HEAD W/O CONT
- Group of 161: CT HEAD W/O CONT
- Group of 161: CT HEAD W/O CONT
- Group of 161: CT HEAD W/O CONT

Image Thumbnails (Right):

- DERMATOLOGY NOTE: NOTE 93/16/2007 22 24 (Skin lesion with ruler)
- CHEST 2 VIEWS PA&LAT RAD CR 03/17/2009 15:00 - 2 Images (Chest X-ray)

ECG (Bottom): 08/17/2009 08:11:30 Resting Dermo Site. Leads: I, aVL, V2, V5.

Order Entry

- Order entry: clinicians make decisions and take actions
- E.g. check vital sign three times a day, take one finasteride once a day, order blood test
- Computer assist and document this process

Order Entry Example using an informatics tool

- Fig 12.3
- Vanderbilt Total Parenteral Nutrition (TPN)
- Computerized Physician Order Entry (CPOE)

WizOrder Popup PANE #5

TPN fluid requirement must be a least 20 ml/kg/day.

1 TPN fluid requirement: ml/kg/day (not including lipids)
Cycle TPN over hours

2 [<Review Current Lab Trends>](#)
Patient: ZTESTSSS, 7 Do (female) TPN Calculation Weight: 3.8 kg

3 **Amino Acids as Trophamine** grams/kg/day
add Cysteine 0 30 mg/g of protein

Dextrose %

Lipids 20% grams/kg/day over hours
Carnitine (10 mg/kg/day) added if lipids ordered

Sodium mEq/kg/day
Calculated 5000 mEq/liter

Potassium mEq/kg/day
Calculated 500 mEq/liter

Calcium 0 15 mEq/liter 30 mEq/liter

Magnesium 0 5 mEq/liter

Phosphate 15 mmol/liter
(calculated from calcium dose)

Acetate/Chloride
 Minimal Chloride
 1:1 ratio
 Minimal Acetate

4 **Calculate** (Updates Fields)

Amino Acid Calories: 8 kcal/kg/day Fat Calories: 20 kcal/kg/day
Dextrose Calories: 3.4 kcal/kg/day Total Calories: 31.4 kcal/kg/day
Lipid Rate: 1.6 ml/hr Lipid Volume: 10 ml/kg/day
Calculated minimum TPN Rate: 6.3 ml/hr
Calculated minimum TPN Volume: 152 ml/day
Calculated TPN Rate: 1.6 ml/hr
Calculated TPN Volume: 38 ml/day
Total Fluid Volume (TPN + Fat): 20 ml/kg/day

5 **Submit Final Order** OR **Exit Without Ordering**

Added Medications and Supplements
MVI-PEDIATRIC: 5 ml (wt >= 2.5 kg)
Neotrace & Selenium daily M TH
heparin 0 0.25 units/ml

Other Possible Additives
Vitamin K 0 1 mg/day
famotidine (Pepcid) (mg/kg/day) 0 1 2
albumin (g/kg/day) 0 0.5 1

Special Instructions to Pharmacy:

Copyright (C) 2005, Vanderbilt University Medical Center

Oder Entry example 2

- Drug intervention entry

FirstEMR 2.0.9.0 Provider: Doctor FirstDoctor MD; Practice: **Production** Fms_db - [NewCropPageForm]

File Scheduler Encounter e-Prescription Billing Admin Master Help

Carson

Name	Carson,Nadia M.-	MRN #	00002	Last Encounter	10/13/2010 10:57 AM	Status	
D.O.B	5/13/1979	Attending	PodiatryDoctor	Encounter Type	Follow Up Office Visit		
Age	32 years	Referring	Dr. Family	Encounter ID	708	Location	
Sex	Female	CC	pain	Advanced Directive	No		
S.S.N.	XXX-XX-2245	Insurance	CIGNA HEALTH				Apply Status

FirstMedicalSolutions Pharm: 0 Fax: 0 Pend: 53 FirstMedicalSolutions

Select Dr./Staff Compose Rx Med Entry Pt. Details Diagnoses Admin

MedEntry Designated Dr./Prescriber: D. FirstDoctor

PRE-PRODUCTION: THIS IS NOT A SECURE OR LIVE ENVIRONMENT. TEST PATIENTS ONLY.
 The use of REAL PATIENTS is a violation punishable under SECTION 7.2 of the HIPAA Privacy Rule.
 If you believe you are seeing this in error, please contact your EMR or software provider.

Patient: **Nadia M Carson** DOB: **5/13/1979** Gender: **Female** Self-Pay/No Insurance Selected

Encounter ID: cd7ff41a-cd0f-4ecf-aaf3-eb65abf30b4f

Pre-production - From: 64.139.216.16 From IP: 64.139.216.16 AccountID: ~demo~ SiteID: ~demo~ LocationID: ~6536b2f2-75f9-459c-bcea-edb766bdcca5~

Enter optional Outside Doctor and/or Original Start Date before selecting drug.

Replace current doctor: Doctor FirstDoctor Enter Original Start Date: Month Day Year

Select to Move to Current Meds or leave for further processing **Open Edit for Dosing**

Rx Date Stage	Drug	Sig	#	Refill	Doc / Loc Source	EDIT	SEARCH	DELETE
<input type="checkbox"/> 02/09/11 InProc	Singulair 10 mg Tab	1 daily	30	0	FirstDoctor	EDIT	SEARCH	X
<input type="checkbox"/> 12/07/10 InProc	Codeine 30 mg Tab	1 daily	30	0	FirstDoctor	EDIT	SEARCH	X

Drug Search Doctor's List

3 letter min. 5 recommended Include obsolete drugs

Allergy / Intolerance Search

No Allergies have been entered.

memo

Imported Allergies: not included in Drug Review

Click to include Delete

Name	Severity	Notes	Delete
		Seasonal allergies. Sneezing when pollen	

Close

Oder Entry example 3

- Lab test entry

Record specimen reception

Test order

Clinician : GH001, GEORGES, NANA

List lab test requested

	Order code	Date of request	Record number	Firstname	Lastname	Sex	Age
▶	LAB-72	7/6/2015 6:56:54 PM	PT-19	ASAFOATSE	JOELLE	F	6
	LAB-73	7/6/2015 6:56:54 PM	PT-18	NII LANTE	OUNKA	M	19

Laboratory test

Test * : Sputum specimen positive for AFB by microscopy.

Specimen : Sputum

Date reception : Monday , July 06, 2015

Add

Specimens collected

	Lab test	Specimen	Date reception
▶	Enzyme-linked immunosorbent assay	Blood	7/6/2015
	Rapid diagnostic test-RDT.	Blood	7/6/2015
	Sputum specimen positive for AFB by microscopy.	Sputum	7/6/2015

Save Close

Data Capture

Two common methods for data capture:

- 1. Using electronic interface to transfer from other systems, e.g. lab test results, drug orders
- 2. Manual input data, e.g. discharge summaries (narrative text input), ICD diagnosis (code input)

EHR lab report

- Lab report data

The screenshot displays an EHR interface for a patient named Carol Patient. The top navigation bar includes 'Patient lists', 'Carol Patient', and various utility links like 'Help', 'Settings', 'Log out', and 'Lock'. The patient's profile information is shown, including PRN: PC48610, age 64, and enrollment status. The main content area is titled 'Results report' and shows a list of lab tests performed by Santosh Provider. The tests are categorized into LDL Cholesterol, HbA1c, and a Comprehensive Metabolic Panel. Each test result is displayed with a value, a reference range, and a status indicator (e.g., 'Above high normal'). The interface also includes options to edit, send to PHR, and sign all results.

Summary | Timeline | Profile | Results report X

PROVIDER: Santosh Provider | ORDER #: 12345

Laboratory: Practice Fusion Labs | Order #: 11502728 | Accession #: 11502728 | Collection Date: 08/01/2014 09:00am | Received Date: 10/30/2014 05:37pm

LDL Cholesterol

OBSERVATION	RESULT	REFERENCE	DATE/STATUS	PHR	SIGNED
Total LDL Cholesterol - Direct	121 mg/dL Above high normal	<130 mg/dL mg/dL	08/02/2014 08:09pm	ON	<input type="checkbox"/>
SUM Total Cholesterol	210 mg/dL Above high normal	<200 mg/dL mg/dL	08/02/2014 08:09pm	ON	<input type="checkbox"/>

HbA1c

OBSERVATION	RESULT	REFERENCE	DATE/STATUS	PHR	SIGNED
HbA1c	8.2 % Above high normal	<=5.6 %	08/02/2014 05:01pm	ON	<input type="checkbox"/>

COMP. METABOLIC PANEL

OBSERVATION	RESULT	REFERENCE	DATE/STATUS	PHR	SIGNED
Creatinine	1.5 mg/dL Above high normal	0.6-1.1 mg/dL	08/02/2014 08:18pm	ON	<input type="checkbox"/>
Glucose	141 mg/dL Above high normal	70-99 mg/dL	08/02/2014 08:15pm	ON	<input type="checkbox"/>
Potassium	4.1 mmol/L	3.5-5.1 mmol/L	08/02/2014 08:13pm	ON	<input type="checkbox"/>
Sodium	133 mmol/L	136-145 mmol/L	08/02/2014 08:13pm	ON	<input type="checkbox"/>

EHR discharge summary

ICANotes Behavioral Health EHR | Chart Room | Chart Face | **Bailey, Mary** | 2004684331 | Patient's Name DOB: 7/21/1973 45 Yrs | Patient's ID

Discharge Summary | Date Admitted: 5/17/2019 | Date Discharged: 5/21/2019 | Delete This Note

Final Exam Summary | Discharge Status & Instructions | Clinician's Narrative | **Included Progress Notes**

Course of Treatment:
Chart Notes

Filter Notes by Type >> **Show All**
>> Showing 4 of 5 Notes
(Discharge Summaries are filtered out)

Date	Note Type	Include this Note in Discharge Summary?
5/21/2019	Progress Note	<input checked="" type="checkbox"/> Yes
5/20/2019	Progress Note	<input checked="" type="checkbox"/> Yes
5/17/2019	Complete Evaluation / Inpatient	<input checked="" type="checkbox"/> Yes
7/17/2017	Progress Note	<input type="checkbox"/> Yes

Compile Course of Treatment with marked Notes, then Preview Discharge Summary
3 Note(s) Selected

with marked notes then Preview Discharge Summary

Section Titles:

- Initial Psychiatric Assessment
- Course in Treatment
- Clinician's Narrative
- Discharge Status and Instructions

Service Code
99239, Discharge Day, long

Select All | Select All in List Above | Clear All

EHR ICD Code input

- Diagnosis coding
- Billing

Diagnosis > Record diagnosis


F41.9 Anxiety disorder, unspecified Edit

Associate diagnosis with encounter 11/08/2017

ACUITY [Clear](#)


Chronic START DATE: MM/DD/YYYY Today


Acute STOP DATE: MM/DD/YYYY Today

MEDICATIONS ASSOCIATED WITH DIAGNOSIS [Add](#) 

MAPPED CODES [Hide](#)

TYPE	CODE	DESCRIPTION
ICD-9	300.00	Anxiety state, unspecified
SNOMED CT	197480006	Anxiety disorder

COMMENT [Add](#) 

ENCOUNTER COMMENT [Add](#) 

RESOURCES

- Patient education materials

Buttons: Cancel, Add another, Save

practice fusion

Patient lists James Patient X

James Patient PRN: PJ246704 63 yrs M Patient Portal: Pending Aetna DOB: 12/30/1952 M: (666) 123-4567

Summary Timeline Profile Order 1604GWA... 05/03/2016 X

8:59 PM Go to... Search

Refresh to update clinical decision support (CDS) notifications below. 8 total notifications

Chief complaint Edit

Cough (Appt time: 1:00 PM) (Arrival time: 8:43 PM)

Flowsheets Edit US Customary Show growth charts

Vitals Add column Last 5 encounters or labs Print Edit Refresh

	05/01/15 10:22 AM	09/28/15 10:24 AM	12/30/15 10:25 AM	04/28/16 10:26 AM
▼ Vitals				
Height	71 in	71 in	71 in	71 in
Weight	175 lb	177 lb	174 lb	170 lb
BMI	24.41	24.69	24.27	23.71
BMI Percentile				
BP	115/80 mmHg	120/80 mmHg	115/80 mmHg	115/70 mmHg
Temperature	98.4 °F	98.6 °F	99 °F	98.5 °F
Pulse	95 bpm	97 bpm	96 bpm	95 bpm
Respiratory rate	13 bpm	13 bpm	14 bpm	13 bpm
O2 Saturation	98 %	97 %	98 %	96 %

Diagnosis > Record diagnosis

ADD DIAGNOSIS* Hide codes in search

cough

Cough	ICD10: R05	ICD9: 786.2
Cough fracture	ICD10: R05,S22.41xA,S22.41xB,...	ICD9: 807.00
Productive cough	ICD10: R05	ICD9: 786.2
Coughing up blood	ICD10: R04.2	ICD9: 786.30
Chronic cough	ICD10: R05	ICD9: 786.2
Effective cough	ICD10: R05	ICD9: 786.2
Does not cough	ICD10: R05	ICD9: 786.2

Add custom diagnosis for "cough"

Buttons: Cancel, Add

Displaying Physician Entered Data

- Charts: Problem list, medication, diagnosis
- Images: x-ray, MRI
- Forms: lab test results
- Textual narratives: e.g., discharge summary

Data Display – Timeline (P412, Fig 12.12)

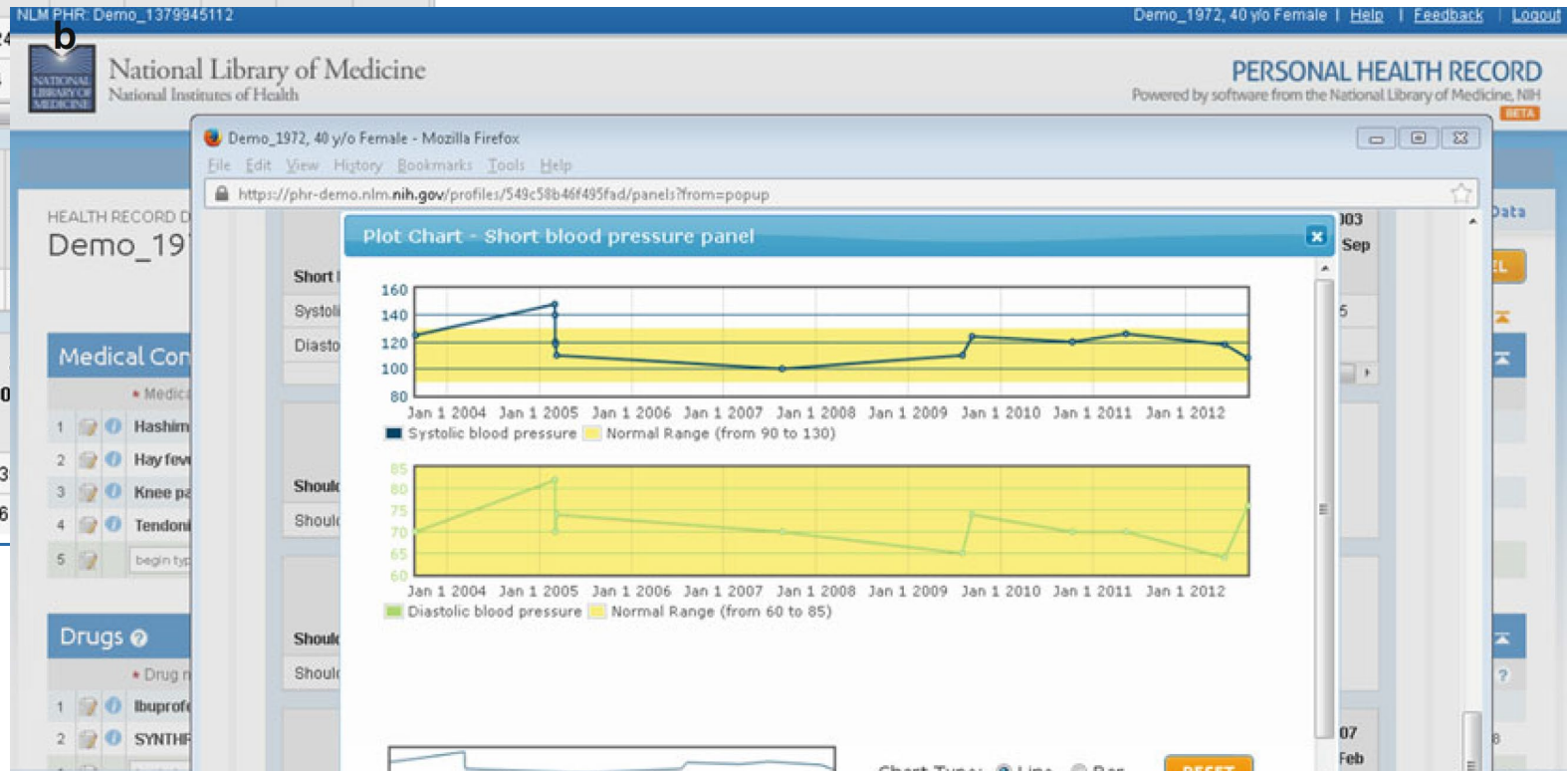
a

	2012 20 Oct	2012 10 Oct	2012 04 Oct	2012 28 Sep	2012 18 Sep	2012 14 Sep	2012 10 Sep	2012 23 Aug	2012 22 Aug
Pedometer tracking panel									
Number of steps in unspecified time Pedomete	10156	9210	9680	9214	8650	8000	6800	2470	8000

	2012 02 Sep	2012 03 Jun	2011 09 May	2010 10 Oct	2009 08 Sep	2009 01 Aug	2007 19 Aug	2005 11 Mar	2005 07 Mar	2005 06 Mar
Short blood pressure panel										
Systolic blood pressure (mm Hg)	108	118	126	120	124					
Diastolic blood pressure (mm Hg)	76	64	70	70	74					

	2012 01 Jan	2010 01 Dec	2009 01 Nov	2009 01 Jun
Thyrotropin (TSH)				
Thyrotropin (TSH) (mcU/mL)	3.5	3.8	3.4	3.1

	2012 02 Sep	2012 01 Jun	2012 01 Jan	2012 01 Jan
Weight & height tracking panel				
Body weight (pounds)	126	126	128	13
Body height (inches)	66	66	66	66



Data Display – Summaries and Snapshots

(P412)

- Fig 12.15 (P417)

Dayton, Vince
Male, 55 y.o., 12/15/1956
CC: Diabetes Follow-up
Allergies/Reactions: Penicillins
HM: Health Maintenance
Ins: EPIC
MRN: 27299
CSN: 332586
MyChart: Active

Diabetes Navigator | Lab Reports | Filters | Tag Search | Preview | Refresh | Select All | Deselect All | Review Selected | Side-by-Side | Master Report | Lab Flowsheet | Flowsheet | Apply Default Sorting | More

Snapshot | Encounters | Labs | Imaging | Procedures | ECG | Medications | Other Orders | Letters | Episodes | Notes | Outside Records | Media

Report: Snapshot

Problem List

Chronic

- Diabetes mellitus - Type 2
- Essential hypertension
- Obesity
- Hyperlipidemia

Chief Complaint

Diabetes Follow-up

Medications

- hydrochlorothiazide (HYDRODIURIL) 25 MG tablet
- metformin (GLUCOPHAGE-XR) 500 MG 24 hr tablet
- lisinopril (PRINIVIL/ZESTRIL) 5 MG tablet
- simvastatin (ZOCOR) 10 MG tablet

Allergies

Mark as Reviewed

PENICILLINS	Rash
-------------	------

Last Reviewed by on 1/20/1999 at

Significant History/Details

Smoking: Former Smoker (Quit Date:01/06/1999), 1 ppd, 35 pack-years
Smokeless Tobacco: Never Used
Alcohol: 1.0 oz alcohol/week
Comments: Please use first name!
No open orders

Immunizations/Injections

Influenza	10/17/2011, 11/30/1998, 10/22/1997, ...
PPV23 (Pneumococcal polysaccharide)	8/24/2001
Tetanus-Diphtheria	1/17/1992

Health Maintenance

Late Due Soon Hold

Topic	Due	Most Recent Outreach
Colonoscopy	12/15/2006	
Hgb A1c (Q 3mo)	3/14/2012	
Influenza Vaccine	10/17/2012	
Tetanus Immunization	12/16/2018	

Care Team and Communications

Referring Provider
No referring provider set

PCPs	Type
Drew Walker, M.D.	General

Other Patient Care Team Members
Relationship

None

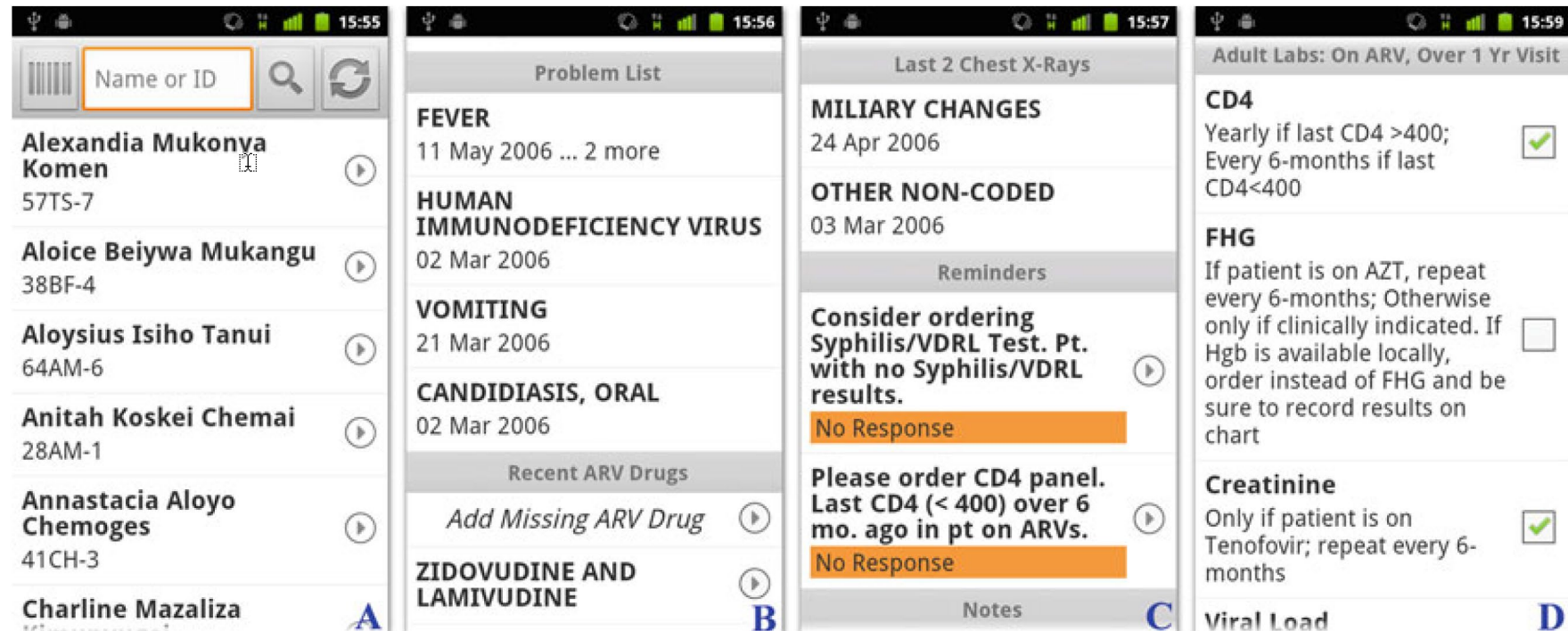
Visit Treatment Team	Relationship
Patty Cling, M.D.	Endocrinologist
Lisa Connelly, RN-DM	Diabetes Educator

Recipients of Past Communications
None

DREW WALKER | Results | Rx Request | Patient Call | Cosign-Charts | CC'd Charts | Staff Msg | Pt. Reminder | 2:44 PM

Tablet and Smart Phone Example

- Fig 12.11
- A) a list of patient
- B, C) summaries
- D) lab test results



Example of imaging information (P413-414)

MRIF_TBL_DISPLAY - Microsoft Internet Explorer provided by America Online

Address: http://falcon.lupui.edu:9110/REGEN/0/load/top.subdoc

DEMO, JONATHAN DOE #99999999-8 @REGEN_DEVELOP M Age: 56 years

OVERHAGE, JOSEPH M

Select a patient | Browse Patient Record | Other | Browse Patient Record » Flowsheet

RADIOLOGY	16-Feb-97 06:10	14-May-96 16:10	09-Feb-96 06:10	11-Feb-91	10-Feb-91	24-Jan-91	16-Jan-91 01:20	16-Jan-91	03-Nov-90 09:21	25-Oct-90
<input type="checkbox"/> Abdomen CT	abcess ? 3									
<input type="checkbox"/> Abdomen MRI			Pulmonary cavitation. ? 3							
<input type="checkbox"/> Abdomen XR							IMPRESSION 1. Abnormal but nonspecific bowel gas pattern. ? 1	WISHARD ER nonspecific bowel gas pattern ?		
<input type="checkbox"/> Chest CT										
<input type="checkbox"/> Chest PA & Lat XR				HOSP right fluid NOS bilateral alveolar infiltrate lingula interstitial mark		heart normal bilateral alveolar infiltrate		WISHARD ER LUL infiltrate? overinflation ? 1	IMPRESSION Interval decrease left infiltrate ? 1	WISHARD ER neg ? 1

X-ray report icon X-ray image icon

Address: http://falcon.lupui.edu:9110/REGEN/0/load/top.subdoc

DEMO, JONATHAN DOE #99999999-8 @REGEN_DEVELOP M Age: 56 years

DEMO, USER

Select a patient | Browse Patient Record | Other | Browse Patient Record » Flowsheet

Chronologic Results
Flowsheet
Flowsheet (Advanced)
Clinical Synopsis
REPORTS

CHEST PA & LAT XR
CHEST, 2 VIEW

Click on a thumbnail image to see full image.
These are compressed images for clinical review.

ALL REPORTS
Discharge Summaries
Miscellaneous
Operative
Pathology
Radiology
Face Sheet
Orders

ENCOUNTERS
Brief
Detailed
Master

PRESCRIPTIONS
Inpatient
Outpatient
Advance Directive
Surgery Log

Hide | Logout | Help | Prev image | Next image | Newpat

Query and Surveillance

- Find data and use the searched data for analysis, such as outcome or patient patterns.
- Use the results to support decision making, such as alert and notification based on query results

Health Service Support

- Identify patients based on certain condition
- For example:
 - Due for periodic screening
 - Generating patient calling list
 - Identify patients that need to be notified about new development, such as recall of drug
 - Find candidate patients for review

Clinical Research

- Identify patient who meet eligibility criteria for clinical trials
- Identify a population of patients and analyze their patterns

Quality Reporting

- Use patient data for quality measures
- For example:
 - Treatment outcome
 - Symptom reports
 - Cost analysis
 - Physician efficiency

Support Administration

- Billing
- Claim
- Insurance
- Time management
- Resource allocation

Reading Materials

- Roles of Electronic Health Records (EHRs) and Clinical Data
 - a. Integrated precision medicine: the role of electronic health records in delivering personalized treatment.
 - b. Digital Twins from Personalized Medicine to Precision Public Health

Clinical Decision Support System

EHR: Clinical Decision Support Perspective

- Clinical Decision Support (CDS): the process that provides clinicians, staff, patients, or other individual with knowledge and person-specific information, filtered or present at appropriate times, to enhance health and health care.
- Clinical Decision Support Systems (CDSS)
 - Informatics system offering situation-specific information and recommendation
 - Provide knowledge or analysis to support decision makers



Motivation of CDSS

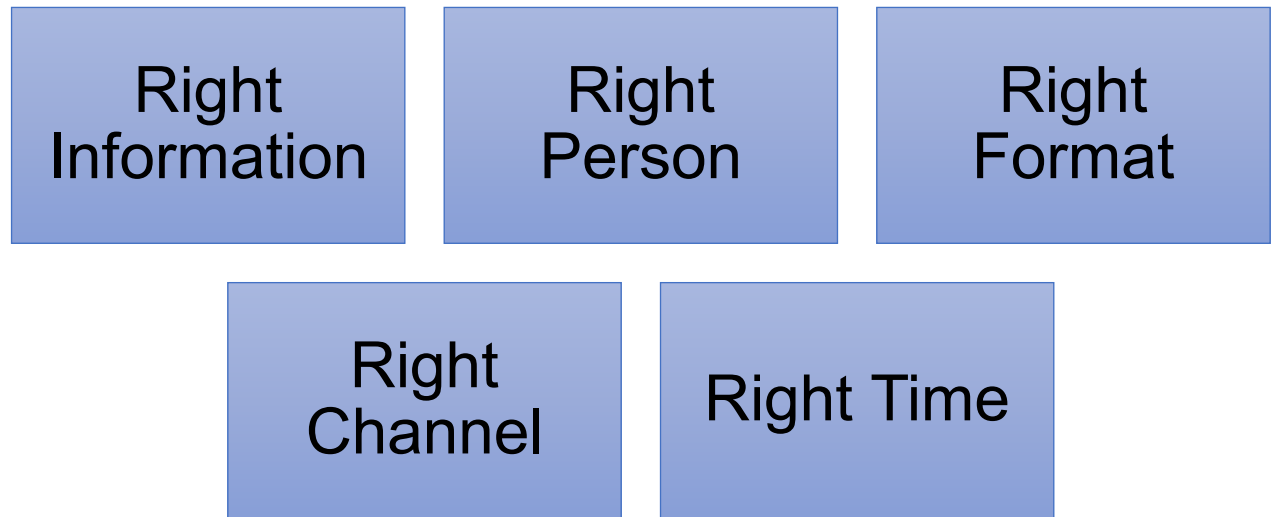
- Challenges of knowledge management and clinical practice
 - Significant growth of data and knowledge
 - Limited time for providers
 - Error due to inadequate patient information
- Meaningful use of electronic health records
 - American Recovery and Reinvestment Act (ARRA) created widespread adoption of health information technologies (HIT)
 - Achieving meaningful use of HIT: safety, quality, efficacy
- Delivering **personalized health services**
 - **Personalized medicine**: the need to tailor care to individual factors – personal factors (clinical and biological), family history, social and environmental factors
 - **Optimize well-being**: not just treating diseases, but changing lifestyle and other behavior to achieve overall healthier condition
 - **Prospective health**: risk assessment based on genomic, family history, social history, environmental history

“Five-rights” model of CDSS

Intervention contains complex triggers, reasoning logics, data processing, and actions, therefore it is essential to provide decision support correctly:

- Provide right information
- To right person
- In the right format
- Through the right channel
- At right time

Can be viewed as general guidelines for designing CDSS



CDS Example

- Fig 12.4
- Antibiotic

a

ADULT ANTIBIOTIC ASSISTANT

000000000 Doe, J.Q. 67Y M ROOM LDS Hospital
Admitted: 06/27/05 16:50 Diagnosis: SEPSIS
WBC is down: Max 24hr WBC: 23.6 Prev.: 27.5 Temp is down: Max 24hr Temp: 37.8 - Prev.: 38.2
Renal Function is Impaired: CrCl = 46 Ur is up: Max 24 Hour Cr: 1.7- Prev. 1.4 IBWeight: 77kg
Antibiotic Allergies: None reported--
Current Antibiotics:
1. 06/27/05.18:24 1day LINEZOLID (ZYVOX), IV SOLN. 600. Q12hrs
2. 06/27/05.18:24 1day FLUCONAZOLE IN NS (DIFLUCAN), INJ 200. Q24hrs
3. 06/28/05.09:12 1day ERTAPENEM (INVANZ), VIAL 1000. Q24hrs

Identified Pathogens	Specimen, Site	Collected
Clostridium subterminale	Peritoneal Fluid,	06/21/05 23:29
Escherichia coli	Peritoneal Fluid,	06/21/05 23:29
Klebsiella pneumoniae	Peritoneal Fluid,	06/21/05 23:29
Enterococcus faecium BL neg VRE	Peritoneal Fluid,	06/21/05 23:29

**** Suggest ID consult ****

Therapeutic Suggestion	Dosage	Route	Interval	Comment
Imipenem	500mg	IV	*q12hr	Infuse over 1hr

Suggested Antibiotics Not Adequate, Call ID

*** Adjusted based on patient's renal function.**
--The antibiotic suggestions should not replace clinical judgement--

OrganismSuscept Drug Info Explain EmpiricAbx Abx Hx ID Rnds Outpatient Models Help

b

- Patient should receive IV antibiotics.
- Renal function dictates that dosage should be adjusted.
- Cultures show fungi or yeast that were not considered pathogens.
- The suggested antibiotic(s) will treat the identified anaerobes.
- Patient's vitals (Temp, WBC, Bands) do not support chest Xray: Wed Jun 22 06:14:00 MDT 2005)
- Suggest vancomycin & an aminoglycoside to empirically treat the Dx of sepsis.
- Suggest ticar/clav or imipenem due to the site of Clostridium infection.
- Prophylactic antibiotics are not suggested for this patient at this time.
- Suggest ID consult based on the complexity of this patient's condition.

CDS Common Implementation

- Commonly provided as reminder or alerts
- Preferable implemented in a way a physician can reject or accept with a click
- Annotate the suggestion with rationales

Alert example

- Significant abnormality of lab test

Messages Patients **Alerts 1** Calls

Low 8/23/18, 11:30 P

Nurse Call
Clara Young, 1IS Room 32

Snooze Call Escalate

Critical Lab Result 3:32 PM

Lab Type Lactate

Lab Value **3.5 mmol/L (Critical)**

Ref Range 0.5 mmol/L - 1.0 mmol/L

View Results

Admit 11:17 AM

Chief Complaint Pneumonia and tachycardia

Admission Time 8/23/2018 T3:28:55Z

Admission Type Inpatient

Location Floor

Add Care Team Members

Alert example

- Adverse drug-drug interaction

Drug Interaction

Contraindicated: Combination may **increase tizanidine levels** with serious CV & CNS effects. [more](#)

Current medication: **tizanidine** 500 mg BID

New medication: **ciprofloxacin (Cipro)** 2 mg TID

Buttons: Stop, Modify (for both medications)

Continue Bo

Feedback | Back | Continue

Not active until one of the choices above are selected

Alert example

- Alert with reference knowledge

Clinical Alert: Asthma

Clinical Alert:

1. Review asthma care plan with patient and/or family.
2. Discuss and recommend the annual flu shot.

Clinical References:

- [Asthma](#)
- [Albuterol](#)
- [Flu shot](#)

Citation:

Bibliographic Citation: This is the Citation for Asthma
Developer: Developer
Funding Source: Funding Source
Release Date: 12/29/13
Revision Date(s): 12/29/15

Continue

Headed to regional soccer championships 10/11.

CDSS: Access to Knowledge

- Provide knowledge resource references to physician when they are writing notes or orders for patients.
- Common knowledge source:
 - National Library of Medicine (NLM): research results, evidence
 - Center for Disease Control and Prevention (CDC): travel, vaccines, out breaks
 - Agency for Healthcare Research and Quality (AHRQ): health care quality comparison, service comparison

Knowledge Ref Example (P401)

- Fig 12.6
- Drug allergic and drug interaction

Oe-Test,George PG CMP LEW
3861812 (MGH) 01/01/1935 (76 yrs.) M PHS INFO SYSTEMS

Home Select Desktop Pt Chart: Medications Oncology Custom Reports Admin Sign Results ? Resource Popup

Warning
You are ordering: CAPTOPRIL
Drug - Allergy Intervention

Alert Message: The patient has a probable allergy: ACE Inhibitor. Reaction(s): Anaphylaxis.

Keep New Order - select reason(s):
 Patient does not have this allergy, will D/C pre-existing allergy

Reasons for override:
 Patient has taken previously without allergic reaction
 Low risk cross sensitivity, will monitor
 No reasonable alternatives
 Other

Continue Order Cancel Back To Search

Oe-Test,George PG CMP LEW
3861812 (MGH) 01/01/1935 (76 yrs.) M PHS INFO SYSTEMS

Home Select Desktop Pt Chart: Medications Oncology Custom Reports Admin Sign Results ? Resource Popup

Warning
You are ordering: CIPROFLOXACIN
Drug - Drug Interaction

Alert Message: Patient is currently on: Warfarin SODIUM Alternating (1MG TABLET MG) PO
Patient is on a Warfarin related anticoagulant and a Fluoroquinolone - May potentate the anticoagulant effect - Concurrent use is not recommended.

Keep New Order - select reason(s):
 Will D/C pre-existing drug

Reasons for override:
 Will adjust dose as recommended
 Will monitor as recommended
 Patient has already tolerated combination
 No reasonable alternatives
 Other

Continue Order Cancel Back To Search

Knowledge Ref - Inforbutton

- Fig 12.8 (P402)

The screenshot displays a clinical laboratory information system interface. At the top, there is a navigation bar with 'Logout', patient information '1234567 • NOLAN, JANET • 1933-01-03 • 78y F • (-) • (FINN, DANIEL, J)', and links for 'MRN', 'Name+', 'List', and 'Add to list'. Below this is a search bar and a 'Laboratory' section for the date range '2011-07-07 to 2011-07-05', with 'Newer' and 'Older' links.

The main content area shows a list of test results. A red circle highlights a specific entry for 'UIBC' with a result of '<55.0'. The entry includes a comment: 'Result not available UIBC 55 ug/dL'. Other tests listed include 'Iron' (41), 'TIBC' (See Comment), and various 'EPOC' and 'Complete Blood Count' tests.

An 'INFOBUTTON MANAGER' pop-up window is overlaid on the right side of the interface. It features an information icon and the title 'INFOBUTTON MANAGER'. Below the title, it prompts the user to 'Select the Concept of Interest' and provides two options: 'Cerner ME DTA: Iron Level' and 'Abnormal Blood Level of Iron'. There are also sections for 'Guidelines' (National Guidelines) and 'Reference' (Lab Tests Online, PubMed). At the bottom, there is a survey link '4-question Survey' and a 'Sponsored by' section from the Department of Biomedical Informatics at Columbia University.

Test	Result
Iron	41
TIBC	See Comment
UIBC	<55.0

Collection time: 2011-07-07 06:56
Last updated: 2011-07-08 15:34
Status: Final, Accno: 21118801189, Perfor

CDSS: Integrated Communication and Reporting

- Support health care across departments or different organizations
- Fig 12.9 (P404): patient handoff report: when the responsibility of care is transferred

Enter Data | Print Report | About

[Handoff History](#) Updated 08 Jul 2011 10:23 by Vawdrey, David K

Code Status FULL CODE	Isolation Status No specific isolation required
Patient Summary Pt is a 86 yo M with PMH of CAD s/p , AS s/p AVR, severe OCP, and 7 mo hx of wheezing presents with cough, wheezing, and dyspnea for 2 d. Pt was initially 98% RA and doing well but then acutely desaturated. Has continued to have moderate-to-high suction requirements today.	Primary Team To-Do List <input type="checkbox"/> TTE <input type="checkbox"/> f/u blood cx --abnormal <input type="checkbox"/> vanc trough before 4th dose 12am 8-2 <input type="checkbox"/> f/u Bcx, Ucx's from fever <input type="checkbox"/> foley placed for urinary retention 600cc retained <input type="checkbox"/> AM PTT <input type="checkbox"/> Contact PMD
Notes/Comments negative mycoplasma CT chest: Findings: Right-sided pacemaker with lead in the right ventricle. The patient is status post median sternotomy and CABG. Evaluation of the lower neck and superior mediastinum are limited by the patient's body habitus. No significant axillary, mediastinal, or hilar lymphadenopathy is identified though evaluation is limited by the lack of intravenous contrast and body habitus. The heart is enlarged. No pericardial effusion is visualized. There are no pleural effusions.	Coverage Team To-Do List <input type="checkbox"/> PA Transport for CT Head <input type="checkbox"/> Sz? Follow head CT read. If bleed, call neurosurg/family/attending. <input type="checkbox"/> f/u cultures <input type="checkbox"/> Follow up on PM lytes/labs. Replete as needed. <input type="checkbox"/> PM PTT ** pan culture, CXR if spikes
Discharge Planning	Consultant Notes/Comments

Reading Materials

- Clinical decision support systems (CDSS) implementation and its application in precision medicine
 - a. Clinical informatics accelerates health system adaptation to the COVID-19 pandemic examples from Colorado.
 - b. Clinical decision support systems for improving diagnostic accuracy and achieving precision medicine.

- Thank you!

- Jake Luo, PhD

jakeluo@uwm.edu