

Clinical Data

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What are clinical data? [1]

- A datum is a single observation of a patient
- Clinical data are a collection of observations about a patient
- Each datum has five elements:
 - the patient (Amr Jamal)
 - the attribute (heart rate)
 - the value of the attribute (52 beats per minute)
 - the time of the observation (1:00 pm on 1/1/2015)
 - the method by which the attribute was obtained (heart monitor)

Types of clinical data [1]

- ❖ **Narrative:** recording by clinician- maternity history
- ❖ **Numerical measurements:** blood pressure, temperature
- ❖ **Coded data:** selection from a controlled terminology system example being the term MI that may mean myocardial infarction or mitral insufficiency
- ❖ **Textual data:** other results reported as text
- ❖ **Recorded signals:** EKG, EEG
- ❖ **Pictures:** radiographs, photographs, and other images

Use of clinical data [1]

- ❖ Form basis of historical record
- ❖ Support communication among providers
- ❖ Anticipate future health problems
- ❖ Record standard preventive measures
- ❖ Identify deviations from expected trends example being a growth chart
- ❖ Coding and billing
- ❖ Provide a legal record
- ❖ Support clinical research

Types of clinical data documents [1]

- ❖ **History and physical examination:**

- ❖ by a clinician

- ❖ **Progress notes**

- ❖ update of progress by primary, consulting, and ancillary providers

- ❖ **Reports**

- ❖ by specialists, ancillary providers

- ❖ Typical paper chart maintains all patient notes in chronological order, sometimes separated into different components



Assessment of a stable patient [1]

- ❖ Chief complaint
- ❖ History of the present illness
- ❖ Past medical history
- ❖ Social history
- ❖ Family history
- ❖ Review of systems
- ❖ Physical examination
- ❖ Investigations –lab, x-ray, other
- ❖ Assessment plan

Some complications of data [1]

- ❖ **Circumstances of observation**

e.g., how was heart rate taken? pulse? EKG?

- ❖ **Uncertainty**

how accurate is patient reporting, measurement, device?

- ❖ **Time**

what level of specificity do we need?

Some complications of data[2]

- ❖ **Duplication**

- ❖ e.g., multiple records in different departments

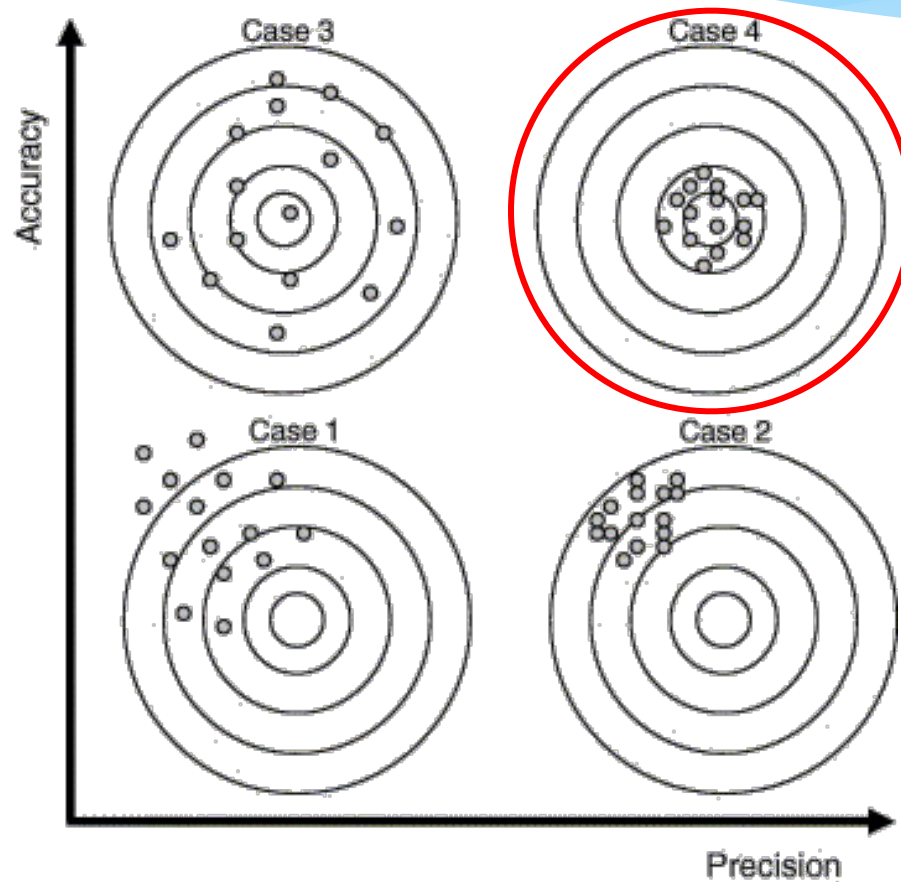
- ❖ **Outdated**

- e.g. missing values

- ❖ **Incorrectly formatted**

- does not follow standards

Imprecision vs. Inaccuracy [5]



Structure of clinical data [1]

- ❖ Medicine lacks uniform structured vocabulary and nomenclature as does Physics and Chemistry
- ❖ Standardization and computerization of data is benefited by standard representations (Cimino, 2007)
- ❖ Counter-arguments are “freedom of expression” and “art of medicine”
- ❖ Narrative information when expressed in many ways can be ambiguous

Personal History:

Name:

Age:

Nationality: Saudi Other:

Sex: male female

Occupation:

Marital Status: Single married Other:

Residence:

Admission Date:

Admission type: Emergency Elective

Ward / Bed:

The Complaint:

Complaint(s)	1.	2.	3.
Duration			

History of Presenting Illness:

Onset			
Duration			
Frequency			
Severity			

We need better access to clinical data [1]

- ❖ Missing clinical information during primary care visits (Smith, 2005)
 - ❖ Information reported missing in 13.6% of clinical visits
 - ❖ Available but outside system in 52% of instances
 - ❖ Estimated to adversely effect patients 44% of time
 - ❖ Unsuccessful searching for it took >5 minutes 35% of time
- ❖ Physicians have two unmet information needs for every three patients (Gorman, 1995; Ely, 1999)
- ❖ Secondary use of clinical data (Safran, 2007)

Data entry [1]

- ❖ General categories of data entry:
 - ❖ **Free-form** entry by historical methods:
 - ❖ writing
 - ❖ dictation
 - ❖ typing
 - ❖ **Structured** (menu-driven) data entry by mouse or pen
 - ❖ **Speech** recognition for either of above



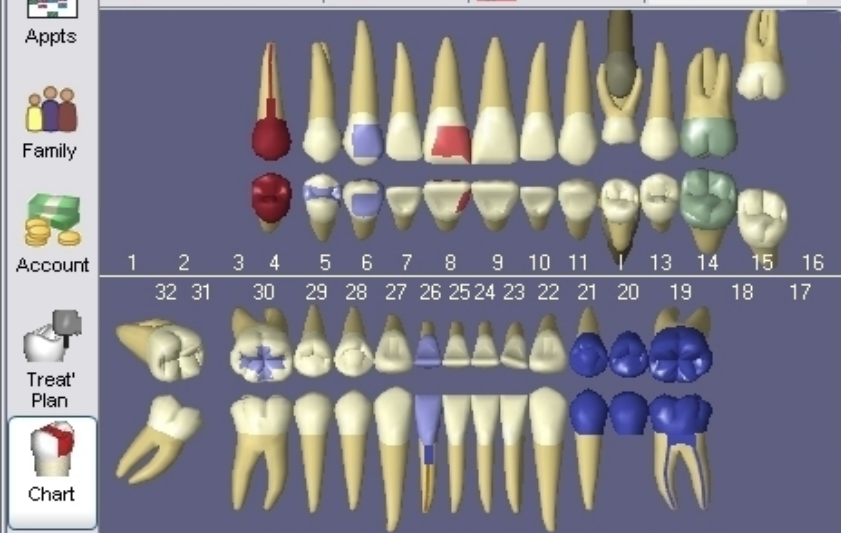
ORCA CPOE order screen

The screenshot shows the ORCA CPOE order screen for a patient named 'zztest_cpoe'. The patient's age is 22 years and their DOB is [redacted]. The patient's allergies are listed as 'No Known Allergies'. The PCP(s) is 'TTBret'. The patient is currently in the 'Emergency' department.

The screen is divided into several main sections:

- Menu:** Located at the top left, it contains a 'Menu - Inpatient' dropdown and a list of clinical notes and orders.
- Med Recon:** A section for medication reconciliation, including buttons for '+ Add', 'Document Medication by Hx', 'Reconciliation', and 'Check Interactions'.
- Status Bar:** Located at the top right, it shows the patient's status as 'Meds History' and provides links for 'Adm. Meds Rec' and 'Disch. Meds Rec'.
- Orders Pane:** The main area for viewing and managing orders. It displays a table of orders with columns for 'Order Name', 'Status', and 'Details'. The orders are categorized into sections: Code Status / Precautions, Diet / Nutrition, Medications, Lab / Path, Diagnostics Other, and Scheduling.
- View Pane:** A sidebar on the left of the Orders Pane that allows users to filter and view orders by category. The categories include: Orders for Signature, Plans, Medical, Orders, Communication, Admit / Tx / Disch, Code Status / Precautions, Vitals / Monitoring, Pt Care / Nursing, Respiratory, Activity, Diet / Nutrition, Infusions / TPN, Medications, Lab / Path, Radiology, Diagnostics Other, Consults / Therapies, DME / Supplies, Scheduling, Medication History, and Reconciliation History.
- Clinical Categories:** A list of clinical categories located on the far left, including: Clinical Notes, Orders, Chart Summary, IVIEW & PowerNote, MINDscape, Epic Web, Results Review, Lab, Radiology, Pathology, Diagnostics Other, I&O Results, Med Profile, Demographic Info, Visits, Allergies, Diagnoses & Problems, Form Browser, Links and Reports, and Advanced Growth Chart.
- Initiate and Sign buttons:** Located in the lower right corner of the screen, these buttons are used to initiate and sign orders.

Order Name	Status	Details
Code Status / Precautions		
Code Status	Discontinued	07/14/11 9:36:00, Code Status: DNR / DNI
Diet / Nutrition		
Full Liquid Diet (Diet Full ...)	Discontinued	07/12/11 13:53:00, SEC DIET TYPE: Carbohydrate Managed Diet
Clear Liquid Diet (Diet Cl...)	Discontinued	07/12/11 13:51:00
Clear Liquid Diet (Diet Cl...)	Completed	07/12/11 13:29:00
Medications		
prasugrel	Discontinued	10 mg, PO, Daily, Start: 07/15/11 9:00:00, Tablet
NonFormulary - Med (Lipitor)	Ordered	Lipitor, PO, Daily, 07/11/11 13:16:00 pt to take own meds
Lab / Path		
Complete Blood Count (...)	Ordered	07/18/11 16:56:00, Routine, Stop: 07/18/11 16:56:00
Diagnostics Other		
Lung Volumes	Deleted	DX: Abnormal Chest X-ray, QUESTIONS ANSWERED: asdf, METH...
Spirometry	Discontinued	DX: Pleural Effusion Pneumonia Unspecified Preoperative Respi...
Somatosensory Evoked ...	Deleted	
Scheduling		
Schedule Laboratory Or...	Ordered	Priority: RT, Any
Schedule Chemo Teach	Ordered	Priority: ROUTINE, Any



PSR 233222
 8-watch
 15 unerupted
 Patient wants his work all done before the middle of July!!!!
 Talked about whitening

Patient Info

ABCO	A
Billing Type	Standard Account
Referred From	yellow pages
Date First Visit	03/17/2005
Pri Ins	Delta Dental of CA. (pending)
Sec Ins	
Med Urgent	
Medical Summary	Acid Reflux High BP
Service Notes	No Flo
Medications	none

Enter Treatment

Missing Teeth Movements Primary Planned Appointment Show

Diagnosis: None, Caries, Recurrent (Car), Incipient (Car), Defect (or miss fill), Missing (tooth struc), Irrevers. Pulp., Revers. Pulp., Necrotic, Apical Perio, Abscess, Carious Pulp Exp, Cracked Tooth

Procedure List: Misc, Exams/Cleanings, Fillings, Dentures

Or Type ADA Code Or Single Click: Amalgam, Composite

Entry Status: TP, C, Ex Cur, Ex Other, Referred

Today
 04/20/2006 no priority

Progress Notes

Date	Th	Surf	Dx	Description	Stat	Prov	Amount	ADA Code
04/05/2005	26		R	PFM Crown	C	DOC1	740.00	D2750
				bs.3 Carps 2%Lido/1:100k epi. Blue bite for temp. Prep. Integrity. 1/4 carp 2%Lido/1:50k epi around tooth, #2 cord, triple tray with PVS putty, PVS light body, Tempbond, PD instr, Shade "A4"				
04/21/2005				Clinical Note	EC	DOC1	0.00	Zclin
				In-Dup pano and bws for?				
04/26/2005	26		R	PFM Seat	C	DOC1	0.00	N4118
				Adjusted, polished, showed to pt, FujiCem. PD instr.				
05/03/2005	8	MF	R	Composite- 2 Surf, Anterior	TP	DOC1	140.00	D2331
				br...2 carps 2%Lido/1:100k epi. L-Pop. Z-250, Shade "A3.5"				
05/17/2005	5	MOD	R	Composite- 3 Surf, Posterior	C	DOC1	160.00	D2393
				In-3 carps 2%Lido/1:100k epi. L-Pop. Z-250, Shade "A3"				
05/17/2005	6	MFL	R	Composite- 3 Surf, Anterior	C	DOC1	175.00	D2332
				In- L-Pop. Z-250, Shade "A35"				
05/24/2005	19			Bridge retainer-Porcelain Fused to Noble Metal	C	DOC1	710.00	D6752
				In-3 Carps 2%Lido/1:100k epi. Blue bite for temp. Prep. Integrity. 1/4 carp 2%Lido/1:50k epi around tooth, #2 cord, triple tray with PVS putty, PVS light body, Tempbond, PD instr, Shade "A35"				
05/24/2005	20			Pontic-Porcelain Fused to Noble Metal	C	DOC1	710.00	D6242
05/24/2005	21			Bridge retainer-Porcelain Fused to Noble Metal	C	DOC1	710.00	D6752
06/07/2005				Clinical Note	EO	DOC1	0.00	Zclin
				In- Dup BW of #19-#21 for ins co.				
06/07/2005				Comm - Insurance				
				mb//sent xray along with claim requested by insurance for issue of pymt to be processed				
06/14/2005				Bridge Seat	C	DOC1	0.00	N4127
				br...Fuji Cem II, Fit Checker.				

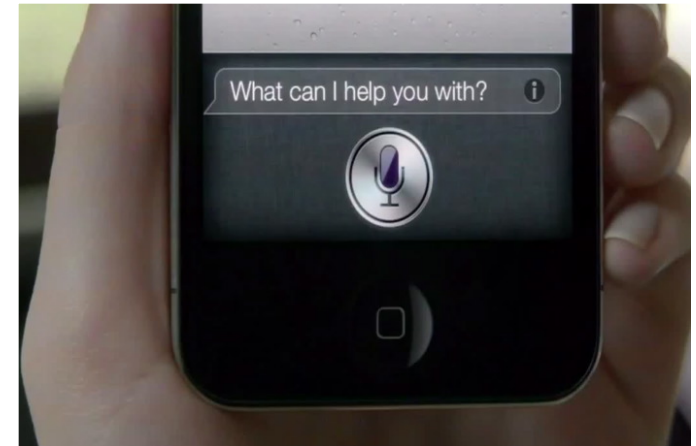
Structured or menu-driven data entry

- ❖ Many attempts from old (Greenes, 1970; Cimino, 1987; Bell, 1994) to new (Oceania; OpenSDE – Los, 2005)
- ❖ Can be done via mouse or pen, with typing
- ❖ Benefits
 - ❖ Data codified for easier retrieval and analysis
 - ❖ Reduces ambiguity if language used consistently
- ❖ Drawbacks
 - ❖ In general, more time-consuming
 - ❖ Requires exhaustive vocabulary
 - ❖ Requires dedication to use by clinicians



Speech recognition for data entry [1]

- ❖ Most common use is for narration
 - ❖ e.g., computer dictation of clinical notes
- ❖ An advantage is instant availability of dictated content
- ❖ Continuous speech recognition now is commercial reality
 - ❖ Speaker-dependent systems require user training
 - ❖ Speaker-independent are systems less accurate
- ❖ Many established systems on the market that operate on:
 - ❖ front-end (used by clinician) or
 - ❖ back-end (process dictations) (Brown, 2008)



iPad 1:47 PM 59%

Katelyn Gleason

Chart ID: GLKA00007 Gender: F Age: 25 DoB: 02/15/1986 555-555-5555

Chief Complaint: unspecified pain or illness

Temperature: 98.0 f Pulse: 60 bpm Blood Pressure: 110 / 65 Respiratory Rate: 20 rpm Oxygen Saturation: 94 %

Height: 68 in Weight: 130 lbs BMI: 19.76 Pain (1-10): 2 Smoking Status: Never Smoker

Clinical Checklist

General WNL

General Comments

HEENT WNL

HEENT Comments

Skin WNL

Skin Comments

coarse hair,

Speech to text in progress

0:00:08

Tap to end

Speech to Text

dr chrono

Lock New eRx eRx Refills Chat Help



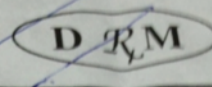
Coded vs. free-text data [1]

- * **Coded data:**

- * Documentation of discrete data from controlled vocabulary

- * **Free text:**

- * Alphanumeric data that are unstructured, typically in narrative form



وصفة طبية
Prescription

13 APR 2013

Date :
Name : Mansha al soukhen M.R. No. : 134415
Age : M F
Diagnosis :

R_x

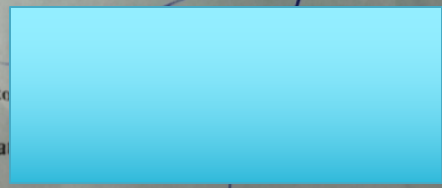
Elan /
me

Signature

1001

Docto

Signa



Narratives tell a story.

- ❖ **A narrative tells a story**

- ❖ See the patient through a description
- ❖ Complicated events are easier to describe in text

- ❖ **Undifferentiated problems**

- ❖ Interpretation.
 - ❖ “only a human can prioritize and determine what the chief complaint really is”



Main Office

Barclay, Joseph MD



Patient: John Dokes **Age:** 47 **DOB:** 03/14/1960
Current Provider: Joseph Barclay MD **Gender:** Male **Current Encounter:** 06/26/2007

New patient
 Established patient

Specialty
Visit Type
Historian

[Referring MD | PCP Info](#)
[Alerts](#) [Patient Service info](#)

Reason(s) for visit	Brief Visit
cough	F.U <input type="checkbox"/>
headache	F.U <input type="checkbox"/>
	F.U <input type="checkbox"/>
	F.U <input type="checkbox"/>
	F.U <input type="checkbox"/>
	F.U <input type="checkbox"/>

Chronic Problem List	Add new problem
Chronic Problem	Code

[Add to today's assessments ?](#)

Vitals **Vital Signs Outside Normal Range** [Add New Vital Signs](#) [Expand Vital Signs](#)

Date / Time	Temp F	Temp C	BP	Pulse	Rhythm	Respiration	Ht In	Ht Cm	Wt Lb	Wt Kg	Conte
06/26/2007 12:00 PM	96.4		130/90	80	regular	16	71.0		216.00		dress

Medications **No Medications** [Comment](#) **Allergies** **No Known Allergies** [Comment](#)

Medication	Dose	Sig Codes	Start Date	Stop Date	Ingredient/Allergen	Brand Name
SIMVASTATIN	10MG	1T PO OD	//	//		

Health Monitor: [Set Health Maintenance Protocols](#) [Set Disease Management Protocols](#) **Tobacco User:** yes quit

	Due:		Due:		Due:		Due:
Physical Exam	//	Tetanus	//	Eye Exam	//	ALT/AST	//
Lipid Panel	06/26/2007	PSA Test	//	Foot Exam	//	CPK	//
Colonoscopy	//			HgbA1C	//	Urinalysis	06/26/2007
Sigmoidoscopy	//			BMP Fasting	//	Urine Micro	//
FOBT x3	//			EKG	06/26/2007	TSH	//
Influenza Vac	//			Stress Test	//	PFT	//
Pneumo Vac	//			Echocardiogram	06/26/2007	Chest X-ray	//

- HOME**
- Demographics
- Record Vital Signs
- Nurse Documentation
- Chart Summary
- View Results
- Allergies
- Immunizations
- Past Medical History
- Family History
- Social History
- Health Maintenance
- HPI / Problem List
- Review of Systems
- Physical Exam
- Procedures
- Assessment
- Disease Management
- Plan / Lab / OS / Diag
- Document Library
- E&M Coding

- Coumadin
 - Adult Office Visit
 - Echocardiogram
 - Nutrition Assessment
 - Stress Master
 - Stress Nuclear
- [Preview](#) [Offline](#)

Navigation pane with folders and icons:

- New
- Lock
- 06/26/2007 12:00 PM
 - Master Im
 - Master Im Vitals
 - Medication
 - Adult Office Visit
 - Disease Mngt
- Custom
- Calendar icon
- Document icon
- Chart icon
- Medical icon (cross)
- Pharmacy icon (D)
- Lab icon (flask)
- Pharmacy icon (mortar and pestle)
- Document icon
- Lab icon (test tubes)

Ian TEST DOB 28/2/2008 GA 26+2 BW 1070

Liverpool 2170

MRN 123432

Day 33 - Corrected GA 31+0 1250g on 01/04

Log Files (0) Images (2) Calculator

ATTENTION: Brain scan overdue:

Current Status

Admissions **Respiratory** **Nutrition** **Other** **Treatments** **Test Results**

Respiratory Support

CPAP /5 , FIO2 29

Admission Planning Discharge

Liverpool Hospital

Admitted: 28/02/08 at 4 hours

Admission Age 0 Corr.GA 26 Weight 1070 76% HC 25.5 71% Length 35 56%

Date & Time 28/02/2008 16:30 Hospital Liverpool Hospital MRN 123432
 Bed 01 To NICU Reason(s) for Admission Prematurity
 Consultant Ian Callander Insurance Hospital Respiratory Distress

Fluids / Feeds

160 ml/kg/day
 TPN 10% Fat 3g
 14x2 EBM 24cal (134)

Jaundice

09/03 SBr 135 Billblanket
 ceased 08/03

Other

01/03 Mod PDA
 POSSIBLE NEC

Treatments

Pentavite, Folic Acid
 Longline,

Test Results

09/03 Na 136
 09/03 Hb 135
 09/03 Plat 265
 02/03 HUS IVH II
 01/04 Eyes ROP I

Opened 01 Apr 12:27

MATERNAL HISTORY

Ann is a 28 year old G2 P1 (now) woman whose blood group is O positive. She was booked to deliver at Campbelltown Hospital under the care of Kaisher however delivered at Liverpool Hospital under the care of Dr Peter Hammill. She had a history of essential hypertension. This pregnancy was complicated by hypertension of pregnancy, fetal growth restriction, Bilateral Renal Pelvis dilatation 5 - 10mm, GBS +ve swab, fever, abnormal Dopplers, prolonged rupture of membranes for 2 days, clinically suspected chorioamnionitis. Ann was treated with antenatal steroids, tocolytics, and antihypertensive drugs. Following the spontaneous onset of labour, she proceeded to a vaginal delivery. Antibiotics were given before delivery.

PERINATAL HISTORY

Ian was born at 13:00 hours with a birth weight of 1070 grams (76th centile). Apgars were 3 at 1 minute and 7 at 5 minutes respectively treated with intubation and ventilation. The arterial cord pH was 7.24 and the base excess -6. Ian was then retrieved to

Added to Worksheet 01/03

Orders on Worksheet 01/03

This is freetext

Freetext orders (double click on text to delete)

Hospital Episodes	MRN	Admitted	Discharged
Liverpool Hospital	123432	28 Feb 2008 16:30	
NETS	PD12345	28 Feb 2008 15:00	28 Feb 2008 16:30
Campbelltown Hospital	222222	28 Feb 2008 13:00	28 Feb 2008 15:00

Add Another Admission

Delete MRN .. then click again to Delete Episode



Add Twin

local form

Issues with coded data

- ❖ “pick from a list” allows wrong selection
- ❖ compliance concerns
- ❖ over documentation for care
- ❖ cloning



Data Management [2]

File Organization concepts

- Database: A set of related files
- File: Collection of records of same type
- Record: A set of related field
- Field: Words and numbers

Database

Radiology

Registration

Financial

File

Name	Age	Medical Summary
Abdullah AlSaif	21	BP
Khalid AlQahtani	34	Acid Reflux
Maryam Badr	42	Pneumonia
Reem Alowais	32	Allergies

Record

Name	Age	Medical Summary
Abdullah AlSaif	21	BP

Field

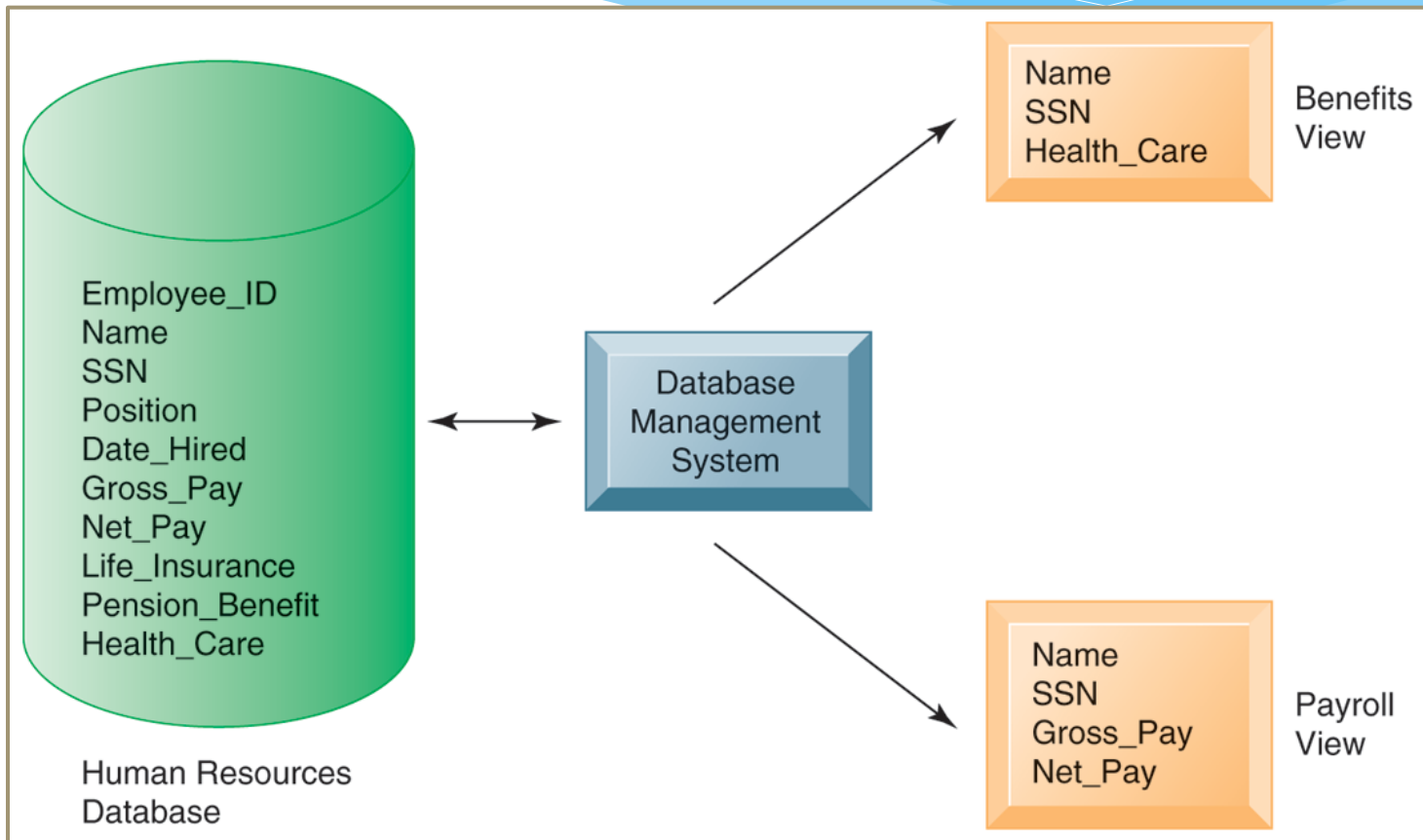
BP (Medical summary field)



Relational DBMS [1]

- ❖ Relational model links records to tables
- ❖ Allows efficiencies
 - One-time information (e.g., demographics) stored only once
 - Complex queries easier to construct and carry out
- ❖ Most query capabilities are based on **Structured Query Language (SQL)**-special language in relational database

Relational DBMS [2]



Big Data [3]



**BIG
DATA**

- ❖ Science of Data Management & analysis
- ❖ **“to convert Vast information and knowledge in organisation to achieve their objectives”** (Murdoch et al, 2013*)
- ❖ What is **BIG/VAST** ? Zettabytes (10^{21} gigabytes) to Yottabytes (10^{24} gigabytes)
- ❖ Used in Astronomy, Search Engines, Financial, Politics and now in Biomedicine
- ❖ Example of Big Data is Bioinformatics (genome, proteomic)

*Murdoch, T. , Detsky, A. (2013) The Inevitable Application of Big Data to Health Care
JAMA. 2013;309(13):1351-1352. doi:10.1001/jama.2013.393.



The FOUR V's of Big Data [3]

40 ZETTABYTES
[43 TRILLION GIGABYTES]
of data will be created by 2020, an increase of 300 times from 2005



Volume
SCALE OF DATA

It's estimated that **2.5 QUINTILLION BYTES** [2.3 TRILLION GIGABYTES] of data are created each day

Most companies in the U.S. have at least **100 TERABYTES** [100,000 GIGABYTES] of data stored

The New York Stock Exchange captures **1 TB OF TRADE INFORMATION** during each trading session



Velocity
ANALYSIS OF STREAMING DATA

By 2016, it is projected there will be **18.9 BILLION NETWORK CONNECTIONS** - almost 2.5 connections per person on earth



Modern cars have close to **100 SENSORS** that monitor items such as fuel level and tire pressure



The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

By 2015 **4.4 MILLION IT JOBS** will be created globally to support big data, with 1.9 million in the United States



As of 2011, the global size of data in healthcare was estimated to be **150 EXABYTES** [161 BILLION GIGABYTES]



30 BILLION PIECES OF CONTENT are shared on Facebook every month



By 2014, it's anticipated there will be **420 MILLION WEARABLE, WIRELESS HEALTH MONITORS**

Variety
DIFFERENT FORMS OF DATA

4 BILLION+ HOURS OF VIDEO are watched on YouTube each month



400 MILLION TWEETS are sent per day by about 200 million monthly active users



1 IN 3 BUSINESS LEADERS don't trust the information they use to make decisions



Poor data quality costs the US economy around **\$3.1 TRILLION A YEAR**



27% OF RESPONDENTS

Veracity
UNCERTAINTY OF DATA

in one survey were unsure of how much of their data was inaccurate

Big Data in healthcare [3]

- ❖ “80% of medical data is unstructured and is clinically relevant.
- ❖ The data reside in multiple places like individual EMRs, lab and imaging systems, physician notes, medical correspondence, claims, customer relations management systems and finance.”

Sources of BIG DATA [4]

- ❖ Clinical Data from CPOE
- ❖ Clinical decision support systems (Written notes & prescriptions)
- ❖ Imaging systems: PACS, Radiology Information systems
- ❖ Sensor data (monitoring vital signs)
- ❖ Social media data- Tweets from Twitter, wall and status updates on Facebook
- ❖ Emergency care data
- ❖ Literature from medical journal

Healthcare BIG data problems to be solved [4]

- * Patient profiles and the health outcomes- identify the effective treatments
- * For public health- identify individuals who would get preventive care or lifestyle changes
- * Analysing literature on medical procedure to determining which care protocols work best
- * Creating mobile apps to manage diabetes. Via Data analytics, we are able to monitor the healthcare outcomes improvements
- * Analysing social network communication among support group members- to understand how non-profit organization can interact and provide help

In summary,

- ❖ Types of clinical data
- ❖ Types of clinical data documents
- ❖ Use of clinical data
- ❖ Access to clinical data
- ❖ Data entry
- ❖ Coded vs. free-form data
- ❖ Speech recognition
- ❖ Big Data
- ❖ Database Management



Acknowledgement



- * Notes are **adapted with permission** from Professor Hersh, Oregon Health and Science University (OHSU), Oregon, USA

References



- [1] Hersh, W. (2014). Notes from 10x10 Medical Informatics certificate, Oregon Health & Science University
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