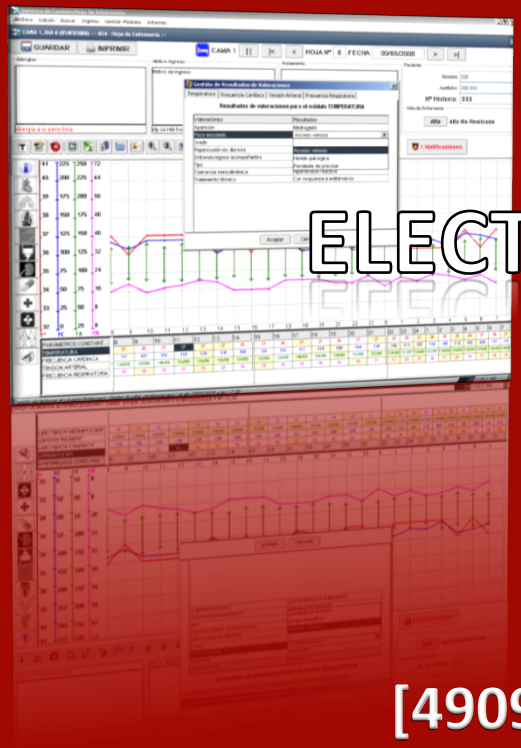

ELECTRONIC HEALTH RECORDS

FACULTAD DE INFORMÁTICA

[4909] Biomedical Information Systems

MSc New Technologies in Computer Science

Jose M. Juarez

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Electronic Health Records

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- Introduction
- Health Records Today
- Electronic Health Records (EHRs)
- Other Aspects of EHRs
- New Challenges: National EHR

Introduction

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1. "*The first*" Health Record (Hippocrates)
2. History of the Health Records
3. Approaches to HR:
   - time oriented
   - source oriented
   - problem oriented

Introduction

Hippocrates from Cos . History attributed the Medical Enciclopedia to him (IV b.C.):

This story starts with the symptoms of Appolinious.

"Apollonius was ailing for a long time without being confined to bed. He had a swollen abdomen, and a continual pain in the region of the liver had been present for a long time; moreover, he became during his period jaundiced and flatulent: his complexion was whitish.
[…]
There were exacerbations of the fever; the bowels passed practically nothing of the food taken, the urine was scanty. No sleep."
[…]

Ἀπολλώνιος ὀρθοστάδην ὑπεφέρετο χρόνον πολὺν. ἦν δέ μεγαλό–σπλαγχνος, καὶ περὶ ἧπαρ συνήθης ὀδύνη χρόνον πολὺν παρείπετο, καὶ δὴ τότε καὶ ἰκτερώδης ἐγένετο, φυσώδης, χροιῆς της ὑπολεύκου. φαγὼν δὲ καὶ πιὼν ἀκαιρότερον βόειον ἐθερμάνθη σμικρὰ τὸ πρῶτον, κατεκλίθη. γάλαξι δὲ χρησάμενος ἔφθοῖσι καὶ ὠμοῖσι πολλοῖσιν, αἰγείοισι καὶ μηλείοισι, καὶ διαίτῃ κακῇ πάντων, βλάβαι μεγάλαι. οἵ τε γάρ πυρετοὶ παρωξύνθησαν, κοιλίη τε τῶν προσενεχθέντων οὐδὲν διέδωκεν ἄξιον λόγου, οὖρά τε λεπτὰ καὶ ὀλίγα διῄει. ὕπνοι οὐκ ἐνῆσαν. ἐμφύσημα κακόν, πολὺ δίψος, κωμα–τώδης, ὑποχονδρίου δεξιοῦ ἔπαρμα σὺν ὀδύνῃ, ἄκρεα πάντοθεν ὑπό–ψυχρα, σμικρὰ παρέλεγε, λήθη πάντων ὅ τι λέγοι, παρεφέρετο. περὶ δὲ τεσσαρεσκαιδεκάτην, ἀφ᾽ ἧς κατεκλίθη, ῥιγώσας ἐπεθερμάνθη. ἐξεμάνη. βοή, ταραχή, λόγοι πολλοί, καί πάλιν ἵδρυσις, καὶ τὸ κῶμα τηνικαῦτα προσῆλθε. μετὰ δὲ ταῦτα κοιλίη ταραχώδης πολλοῖσι χολώδεσιν, ἀκρή–τοισιν, ὠμοῖσιν. οὖρα μέλανα, σμικρά, λεπτά. πολλὴ δυσφορίη. τά τῶν διαχωρημάτων ποικίλως. ἦ γὰρ μέλανα καὶ σμικρὰ καὶ ἰώδεα ἢ λιπαρὰ καὶ ὠμὰ καὶ δακνώδεα. κατὰ δὲ χρόνους ἐδόκει καὶ γαλακτώδεα διδόναι. περὶ δὲ εἰκοστὴν τετάρτην διὰ παρηγορίης. τὰ μὲν ἄλλα ἐπὶ τῶν αὐτῶν, σμικρὰ δὲ κατενόησεν. ἐξ οὗ δὲ κατεκλίθη, οὐδενὸς ἐμνήσθη. πάλιν δὲ ταχὺ παρ–ενόει, ὥρμητο πάντα ἐπὶ τὸ χεῖρον. περὶ δὲ τριηκοστὴν πυρετὸς ὀξύς, διαχωρήματα πολλὰ λεπτά, παράληρος, ἄκρεα ψυχρά, ἄφωνος. τριηκοστῇ τετάρτῃ ἔθανε.

Figure 7.1
Description of a disease by Hippocrates 2,600 years ago. The patient history is that of Apollonius.

Figure from Bemmen-Musen: Handbook of Medical Informatics. Springer

Introduction

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- Hippocrates' text advocated that the patient record serves 2 goals:

1. To reflect the **course** of disease.

2. To indicate the possible **causes** of disease.

Introduction

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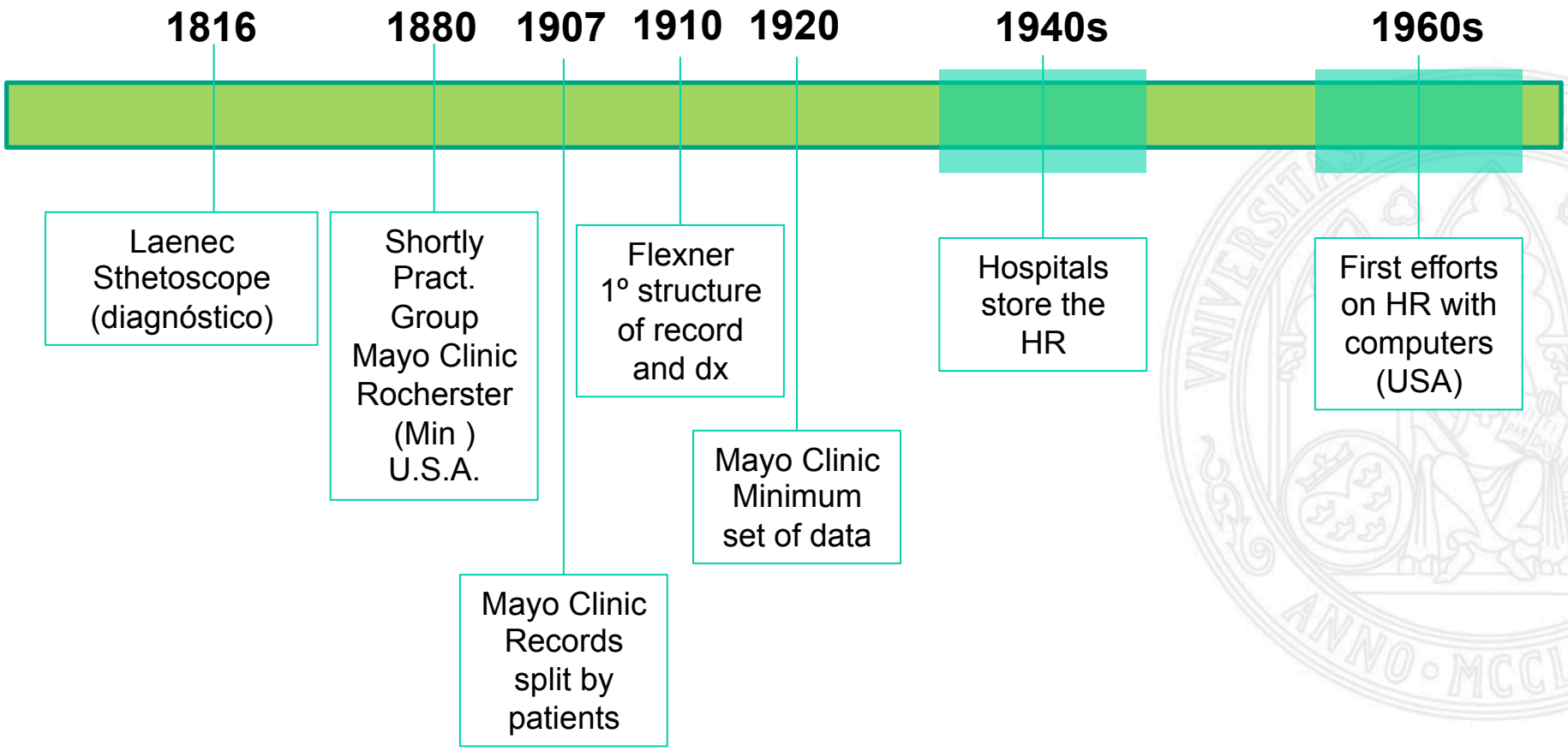
- Health Record history



Introduction

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- Time-Oriented Health Record
  - Chronological view of visits
  - Reflects the story of the patient

  - Not structured
  - Difficult to compare the patient's evolution

Introduction

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- Time-Oriented Health Record

Visits	
21 /Feb/2012	Shortness of breath, cough and fever. Black feces. Exam: RR 150/90, pulse 95/min, Temp. 39.3ºC, Rhonchi, abdomen no tender Present medication: 64 mg Aspirine/day. Probably acute bronchitis, possibly complicated with cardiac decompensation. Bleeding possibly due to Aspirin. ESR 25mm, Hb 7.8, occult blood feces+. Chest X-Rays: no atelectasis, slight sign of cardiac decompensation. Medication: Amoxicilyn 500mg twice daily , Aspirine reducd at 32 mg/ day.
04 /Apr/2012	No more cough, slight shortness of breath, normal feces Exam: slight rhonchi, RR 160/95, pulse 82/min, Keep Aspirin at 32 mg/day. Hb. 8.2, occult blood feces.

Introduction

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- Source-Oriented Health Record

  - Structure priorizes information source
  - Structure: critical decision

  - Redundancies
  - Effective structure (or not) depending on the context.

Introduction

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- Source-Oriented Health Record

Visits	
21 /Feb/2010	Shortness of breath, cough and fever. Black feces. Exam: RR 150/90, pulse 95/min, Temp. 39.3ºC, Rhonchi, abdomen no tender Present medication: 64 mg Aspirine/day. Probably acute bronchitis, possibly complicated with cardiac decompensation. Bleeding possibly due to Aspirin. ~~ESR 25mm, Hb 7.8, occult blood feces+.~~ ~~Chest X-Rays: no atelectasis, slight sign of cardiac decompensation.~~ Medication: Amoxicilyn 500mg twice daily , Aspirine reducd at 32 mg/day. .
04 /Apr/2010	No more cough, slight shortness of breath, normal feces Exam: slight rhonchi, RR 160/95, pulse 82/min, Keep Aspirin at 32 mg/day. ~~Hb. 8.2, occult blood feces.~~
Lab tests	
21/Feb/2010	ESR 25mm, Hb 7.8, occult blood feces+.
04/Apr/2010	Hb. 8.2, occult blood feces.
Image tests	
21/Feb/2010	Chest X-Rays: no atelectasis, slight sign of cardiac decompensation.

Introduction

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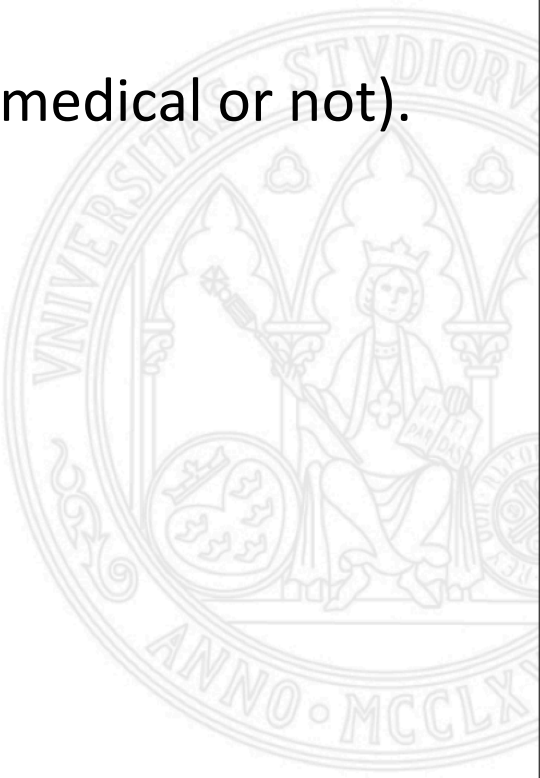
- Problem-Oriented Medical Records
  - Weed 1968
  - Main focus of the study: THE PROBLEMS
  - Problem: any event relevant to the patient (medical or not).

    Ej. Apnea or blackout in the ICU.
  - Based on the S.O.A.P. approach:
    - Subjective, Objective, Assessment and Plan.



Introduction

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- Problem-Oriented Medical Record

Problem 1	Acute Bronquitis	
21/02/2010	S	Shortness of breath, cough and fever.
	O	Temp. 39.3ºC, abdomen no tender
	A	Acute Bronquites
	P	Amoxiciline 500mg 2 / day
04/02/2010	S	No tos, falta aliento leve
	O	Shortness of breath, no cough and no fever.
	A	Bronquitis sing minimum
Problem 2	**Shortness of breath**	
21/02/2010	S	Shortness of breath
	O	RR 150/90, pulse 95/min, Rhonchi, Ronquido, RR 150/90. Chest X-Rays: no atelectasis,
	A	Slight sign of cardiac decompensation.
04/04/2010	S	Falta de aliento leve
	O	RR 160/95, pulse 82/min
	A	No descompensation
Problem 3	**Black Feces**	
…	…	

Electronic Health Records

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- Introduction
- **Health Records Today**
- Electronic Health Records (EHRs)
- Other Aspects of EHRs
- New Challenges: National EHR

2. Health Records Today

I REGRET TO INFORM YOU THAT YOUR SON SUFFERS FROM A WRITTING ATROPHY
(LAMENTO DECIRLO PERO SU HIJO TIENE UNA ATROFIA A LA HORA DE ESCRIBIR)

COOL! I ALWAYS WISH MY SON TO BE A DOC
(¡PERFECTO! SIEMPRE ME HIZO LA ILUSIÓN QUE FUESE MÉDICO!)

The Simpons®. FOX broadcasting company

HR today

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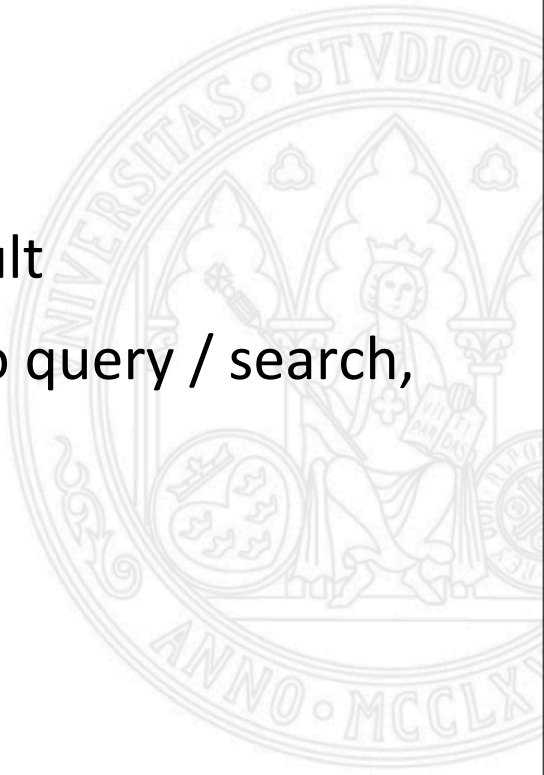
- Today a HR can include: *“Lab results**, X-rays and notes about each visit*”*.

  * Source-oriented: para facilitar estudios

  **Chonologically-oriented following SOAP.

But…

- Chronlology order makes the analysis difficult
- Each documents is independent, not easy to query / search, not easy to manage.



HR today

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- Goals of the HR today:

"The purpose is **remind** observations, **inform** to other professionals, **teach** students, **improve** the knowledge, **monitorize** the patient and **justify** the interventions"

Stanley Reiser 1991

HR today

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- What do we expect?
  - **Care** support:
    - HR as a source to evaluate and decision making.
    - HR as a knowledge source to be shared with other clinicians.
  - **Legal** document describing medical actions.
  - **Research** support: clinical, epidemiological, quality of service, etc.
  - Clinical **education**.
  - Medical **management**:
    - Costs: bills
    - Organization: timetables
    - Management costs.
    - Study of needs.

HR today

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- Problems of current HR:
  1. Heterogeneous documents: hard to control.
  2. Hand writting documents.
  3. Information can be modified.
  4. Security problems: access to information.
  5. Confidenciality under suspect.
  6. Data query is almost impossible.
  7. Mainteinance (costs).

Electronic Health Records

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- Introduction
- Health Records Today
- **Electronic Health Records (EHRs)**
- Other Aspects of EHRs
- New Challenges: National EHR

3. ELECTRONIC HEALTH RECORDS (EHRs)

EHRs

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1. Pros & Cons of EHRs
2. 1st Law of Medical Informatics
3. Components of EHRs:
   - Landscape view, decision support, data typing
   - Medical knowledge access, reporting
4. Essential tasks:
   - Acquisition
   - Presentation
   - Query

EHRs

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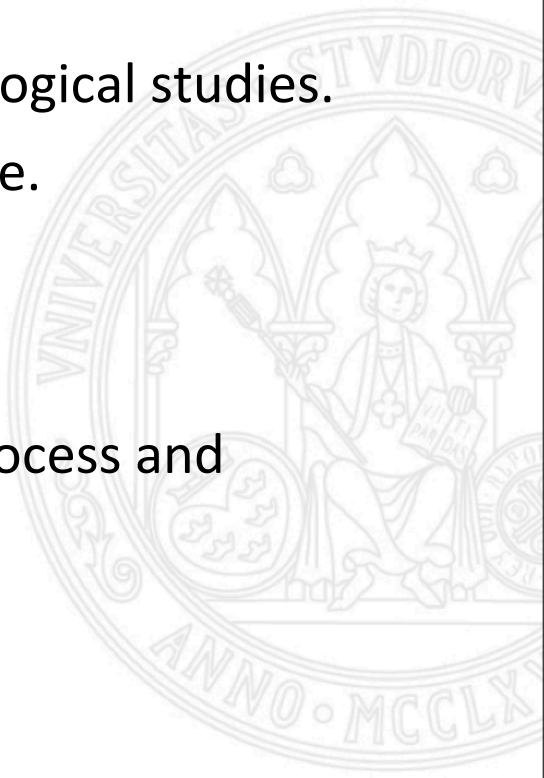
- EHR, does it worth?
  - Pros:
    - Techniques: security, access
    - Clinical aspects: medical research, epidemiological studies.
    - Savings: document warehouses, maintenance.
  - Cons:
    - Data typing.
    - Costs: software development, installation process and teaching.
    - Need of cost-benefit study.



EHRs

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- Example of a Cost-Benefit study of EHR

Table 2.3 A cost–benefit analysis for an electronic patient record (based on estimates from [13] with permission from Elsevier. © 2003 Excerpta Medica Inc.).

	Initial cost	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Costs ($)							
Software license	16 000	1600	1600	1600	1600	1600	
Implementation	34 000						
Support	15 000	1500	1500	1500	1500	1500	
Hardware	6600			6600			
Productivity loss		11 200					
Annual costs ($)	13 100	14 300	3100	9700	3100	3100	46 400
Present value of annual costs ($)		13 585	2798	8317	2525	2399	29 623
Benefits ($)							
Chart pull savings		3000	3000	3000	3000	3000	
Transcription savings		2700	2700	2700	2700	2700	
Prevented adverse drug events			2200	2200	2200	2200	
Drug savings			16 400	16 400	16 400	16 400	
Lab savings					2400	2400	
Radiology savings					8300	8300	
Charge capture					7700	7700	
Prevented billing error					7600	7600	
Annual benefits ($)		5700	24 300	24 300	50 300	50 300	154 900
Present value of annual benefits ($)		5415	21 931	20 834	40 970	38 921	128 071
Net benefit ($)	(13 100)	(8600)	21 200	14 600	47 200	47 200	127 600
Present value of net benefit ($)	(13 100)	(8170)	19 133	12 518	38 445	36 522	85 348

Note: Figures shown in parentheses are negative, i.e. occur in years where costs exceed savings.

Extraído de P. Taylor, “From Patient Data to Medical Knowledge”. Blackwell Publisihing

EHRs

- "1st LAW" OF MEDICAL INFORMATICS:

"Data should be used only for the purpose for which they are collected and that if no purpose was defined prior to collection, they should not be used".

Van Der Lei

EHRs

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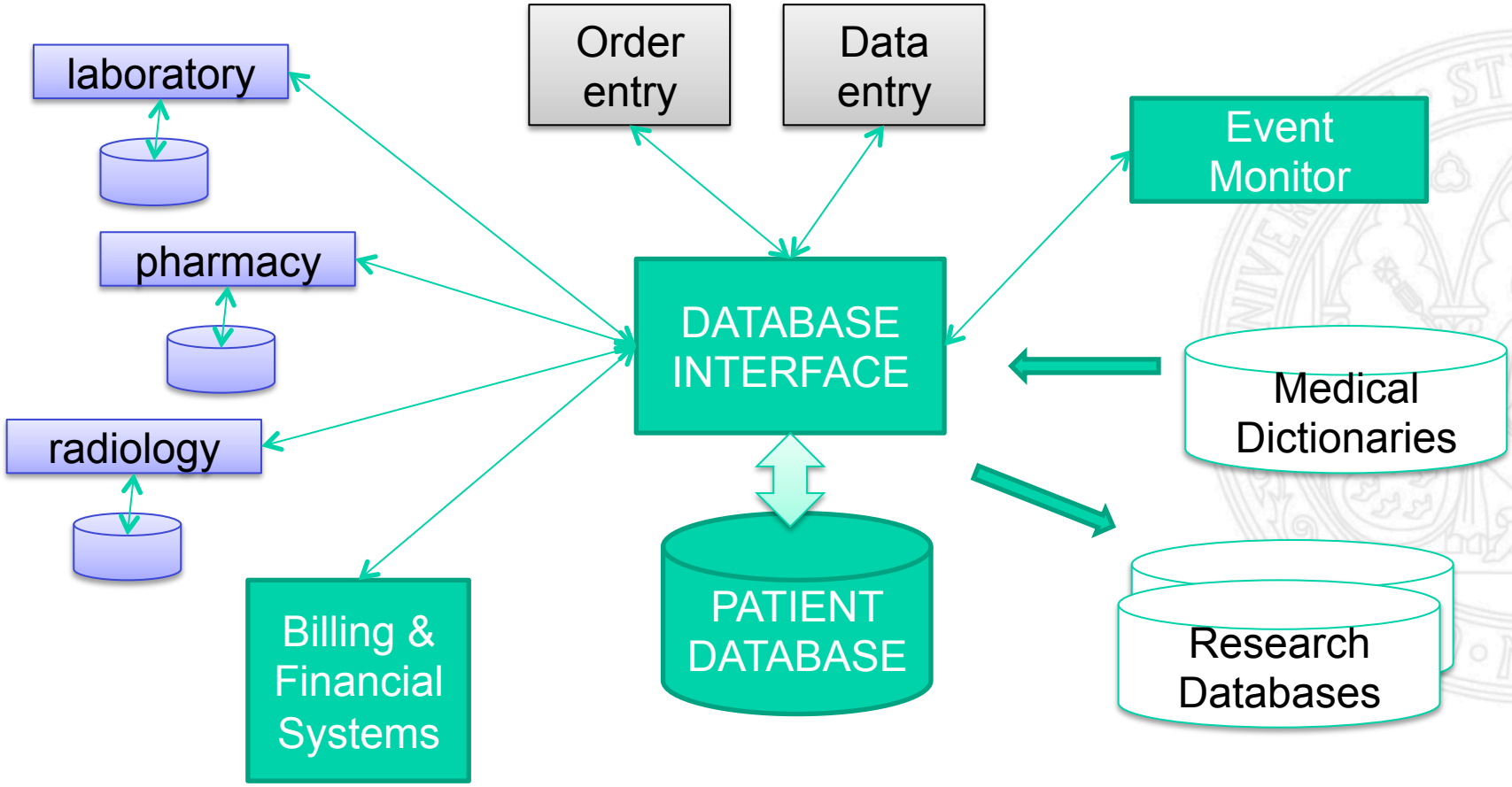
- Functional components of the EHR:
  1. "Landscape" view of the patient.
  2. Decision support.
  3. Data typing support.
  4. Medical knowledge access
  5. Communication and reports

1. “Landscape” view of the patient: data integration



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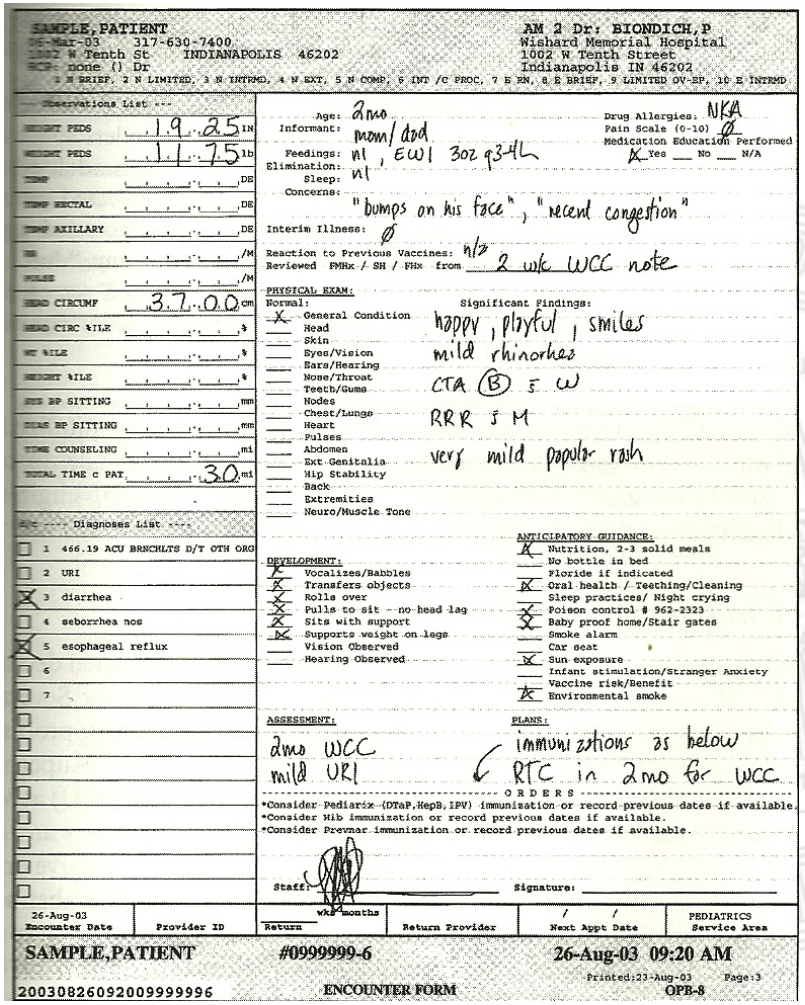
2. Decision support

- Forms to support
- Alert systems
- KBS



SAMPLE, PATIENT
26-Mar-03 317-630-7400
1002 W Tenth St INDIANAPOLIS 46202
PCP: none () Dr

AM 2 Dr: BIONDICH, P
Wishard Memorial Hospital
1002 W Tenth Street
Indianapolis IN 46202

3 B BRIEF, 2 N LIMITED, 3 N INTRMD, 4 N EXT, 5 N COMP, 6 INT /C PROC, 7 E RN, 8 E BRIEF, 9 LIMITED OV-EP, 10 E INTRMD

--- Observations List ---

HEIGHT PEDS	19.25 IN
WEIGHT PEDS	11.75 lb
TEMP	DE
TEMP RECTAL	DE
TEMP AXILLARY	DE
HR	/M
PULSE	/M
HEAD CIRCUMF	37.00 cm
HEAD CIRC %ILE	%
WT %ILE	%
HEIGHT %ILE	%
SYS BP SITTING	mm
DIAS BP SITTING	mm
TIME COUNSELING	mi
TOTAL TIME c PAT	30 mi

A/C --- Diagnoses List ---

1. 466.19 ACU BRNCHLTS D/T OTH ORG
2. URI
3. [X] diarrhea
4. seborrhea nos
5. [X] esophageal reflux
6.
7.

Age: 2mo
Informant: mom/dad
Feedings: nl, EW1 3oz q3-4h
Elimination: nl
Sleep:
Concerns: "bumps on his face", "recent congestion"
Interim Illness: ø
Reaction to Previous Vaccines: n/a
Reviewed PMHx / SH / PHx from 2 wk WCC note

Drug Allergies: NKA
Pain Scale (0-10) ø
Medication Education Performed: [X] Yes ___ No ___ N/A

PHYSICAL EXAM:

Normal:	Significant Findings:
[X] General Condition	happy, playful, smiles
___ Head	mild rhinorhea
___ Skin	
___ Eyes/Vision	
___ Ears/Hearing	
___ Nose/Throat	
___ Teeth/Gums	CTA (B) = W
___ Nodes	
___ Chest/Lungs	RRR = M
___ Heart	
___ Pulses	
___ Abdomen	very mild papular rash
___ Ext Genitalia	
___ Hip Stability	
___ Back	
___ Extremities	
___ Neuro/Muscle Tone	

DEVELOPMENT:
- [X] Vocalizes/Babbles
- [X] Transfers objects
- [X] Rolls over
- [X] Pulls to sit - no head lag
- [X] Sits with support
- [X] Supports weight on legs
- ___ Vision Observed
- ___ Hearing Observed

ANTICIPATORY GUIDANCE:
- [X] Nutrition, 2-3 solid meals
- ___ No bottle in bed
- ___ Floride if indicated
- [X] Oral health / Teething/Cleaning
- [X] Sleep practices/ Night crying
- [X] Poison control # 962-2323
- [X] Baby proof home/Stair gates
- ___ Smoke alarm
- ___ Car seat
- [X] Sun exposure
- ___ Infant stimulation/Stranger Anxiety
- ___ Vaccine risk/Benefit
- [X] Environmental smoke

ASSESSMENT:
2mo WCC
mild URI

PLANS:
immunizations as below
RTC in 2mo for WCC

ORDERS
*Consider Pediarix (DTaP,HepB,IPV) immunization or record previous dates if available.
*Consider Hib immunization or record previous dates if available.
*Consider Prevnar immunization or record previous dates if available.

Staff: Signature:

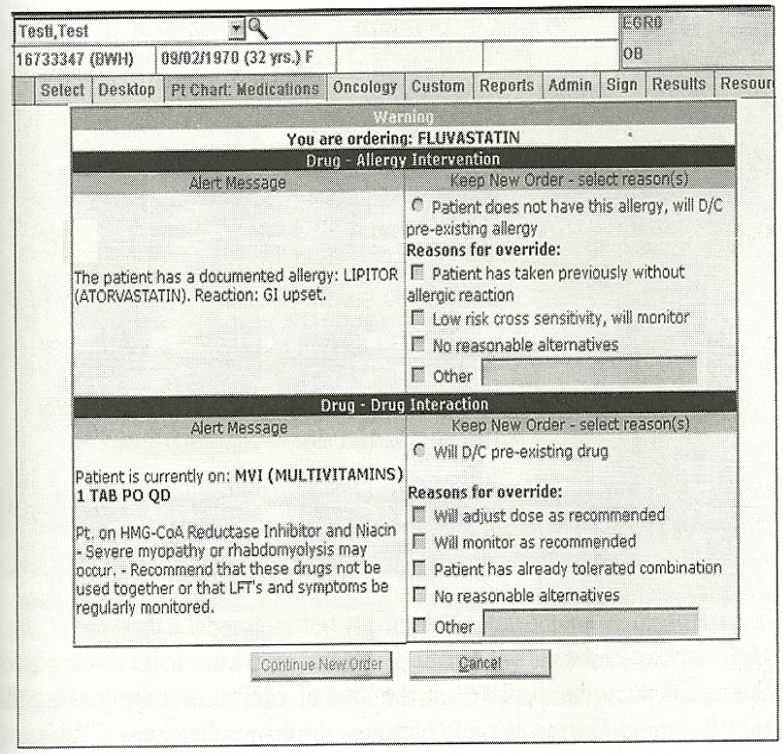
26-Aug-03 Encounter Date	Provider ID	wks months Return	Return Provider	/ / Next Appt Date	PEDIATRICS Service Area

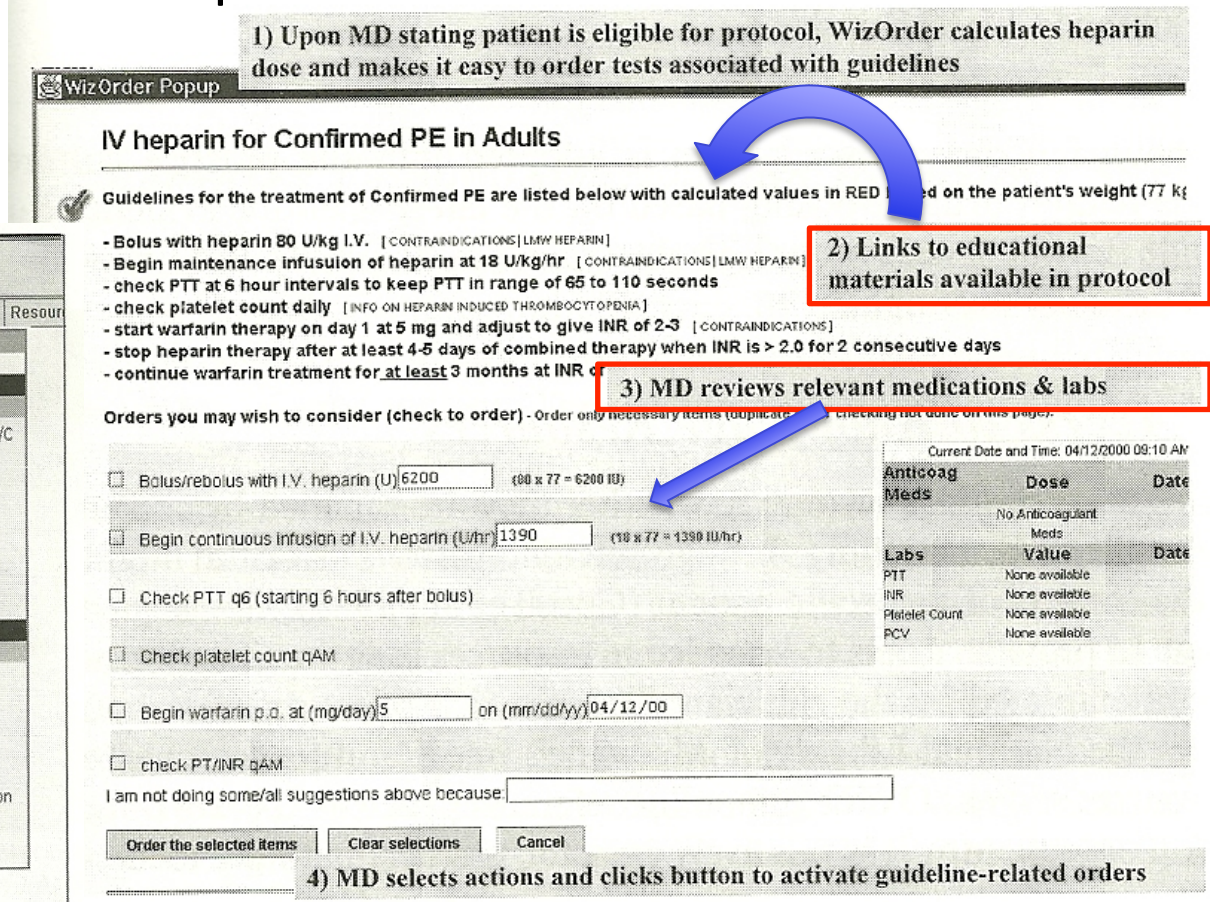
SAMPLE, PATIENT #0999999-6 26-Aug-03 09:20 AM
20030826092009999996 ENCOUNTER FORM Printed:23-Aug-03 Page:3 OPB-8

Formulario de Shortliffe-Cimino Biomedical Informatics, 3rd ed. Springer Ed. 2006

3. Data typing support

E.g. ICU of De Vanderbilt hospital: WizOrder tool

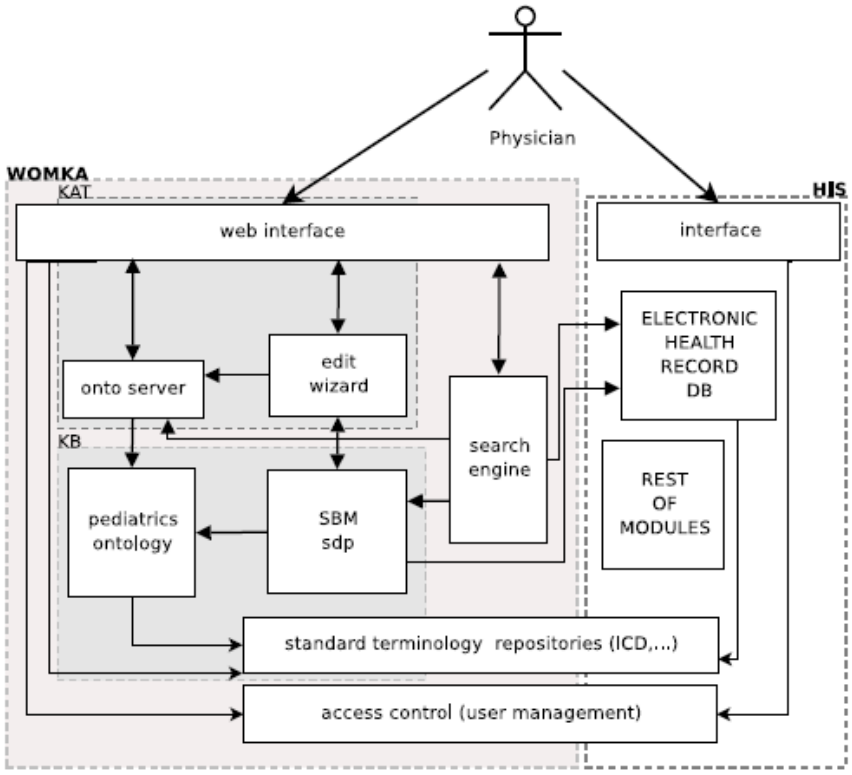


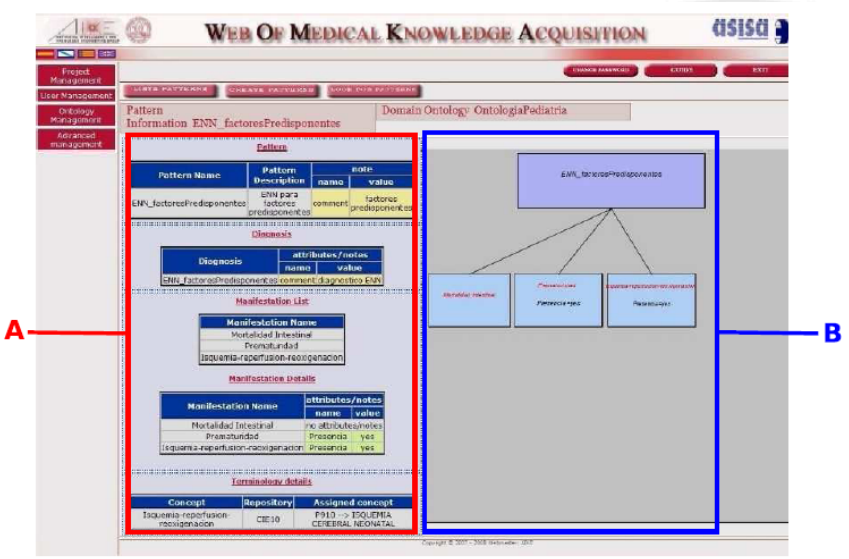


WizOrder, imágenes de de Shortliffe-Cimino Biomedical Informatics, 3rd ed. Springer Ed. 2006

4. Medical knowledge access

E.g. Womka tool





5. Communication and reports

Groupware use:

- asynchronous: messages, forums

Integration with:

- e-mail servers, fax, …

Report generation, automatic summaries.

EHRs

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- Essential tasks of the EHR:
  1. Data acquisition
  2. Data presentation
  3. Queries and surveillance

1. Data acquisition
   - Data sources:
     - Human interaction
     - Data bases
     - Applications and services
     - Devices
   - Aspects to deal with:
     1. Interfaces
     2. Incoming data
     3. Common data introduction
     4. Validation

EHRs

1. Data acquisition: interfaces
   - Dataflows which destination are EHRs:
     - Solved queries: labs, image tests, etc.
     - Queries to other systems: pharmacy, administration, etc.
     - Negotiation (how to proceed): open or company formats?
     - Caducity: data availability, updates.
   - Data obtained:
     - Storing: local?
     - Security: fulfils local and national regulations.
     - Standards: data formats and communication protocols.

EHRs

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1. Data acquisition: incoming data

   (already seen in previous session)

   Human interaction

   1. Free text
   2. Semi-structured text
   3. Sturctured
   4. Codified (standards)

EHRs

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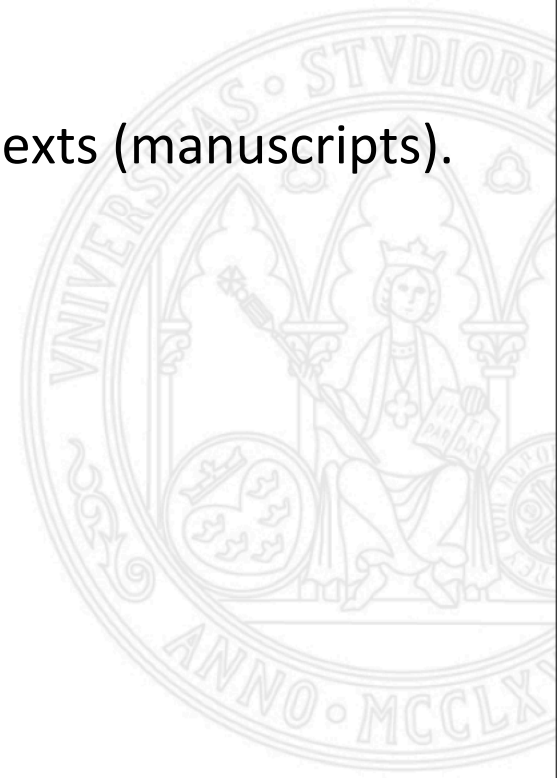
1. Data acquisition: common data introduction
   - Clinicians are busy people: data introduction is not a priority.
   - Common approaches:
     - Transcriptions manually from handwritten texts (manuscripts).
     - Transcriptions by dictations (audio).
     - Forms (checkbox papers)
     - Direct typing.



1. Data acquisition: validation

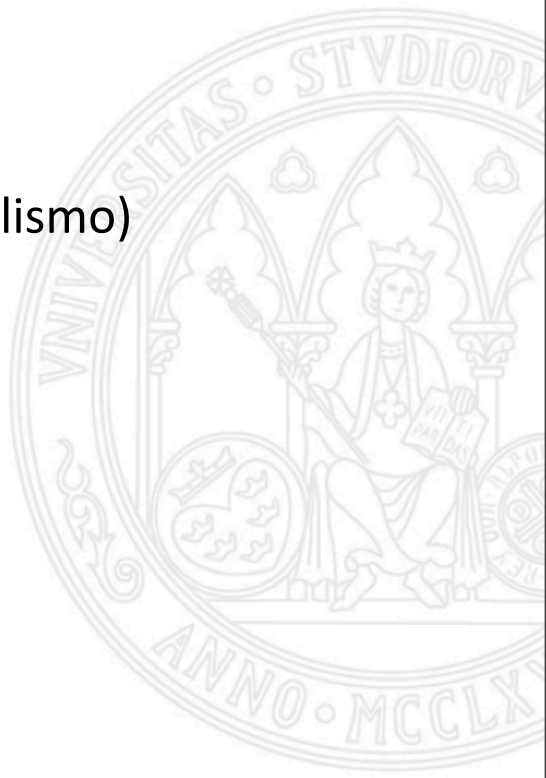
Automatic correctness checking of data guarantees a high quality EHR.

Levels:

(ej. Eparine: dosis subcutánea adulto tras tromboembolismo)

1. Lexic: "Eparine: 1**f** UI/kg-patient"
2. Sintax: "Eparine: 12 **mg**/kg-patient"
3. Semantic: "Eparine: **120** UI/kg-patient"

UI (Unidad Internacional = 100mL)



1. Data acquisition: validation

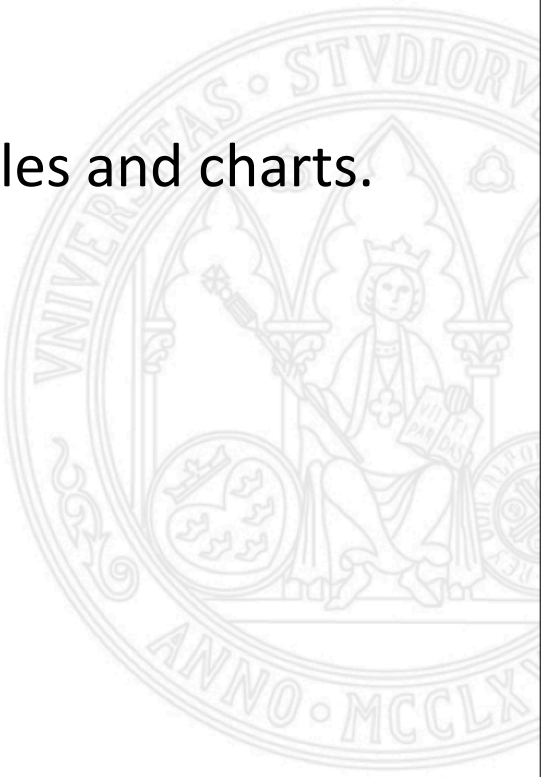
- Rank checking:
  - Ej: Serum Postasium level 50.0 mEq/l

    but the rank must be between (3.5 , 5)
- Pattern checking:
  - To use regular expression .
  - Ej. Telephone:
    - (optional intl code) + 3 digits + space + 6 digits
    - (optional intl code) + 2 digits + space + 7 digits
- Delta check:
  - Alarm due to a sudden change of data values

  E.g. Nurse sheet of a ICU
    - Day 1: Body weight= 75kg Day 2: Body weight =73kg
    - Day 3: Body weight = 57 kg.
- Typo checking:
  - Use of medical dictionaries, achronym lists, vademecums, etc.

2. Data presentation

- Reports with a regularoty/legal effect
- Spread sheets
  - Evolution of the patients by the use of tables and charts.
- Summary
  - Selecting most clinical events
  - Calculating summary of values (statistics).



EHRs

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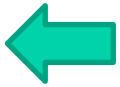
3. Query and surveillance

- Medical care
- Research
- Prospective studies
- Administration

For further information IKTAM course:
Inteligencia de Negocio en Biomedicina



View Summary Dash Boards

Historia Clínica Electrónica

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4. Physical support and ubiquity

- Working place:
  - CP (family doctor) vs. ICU physician
  - ER doors
  - Rotatory nurse team
  - Clinical team in an ambulance
- Getting used to technology.
- Flexibility of hardware changes.

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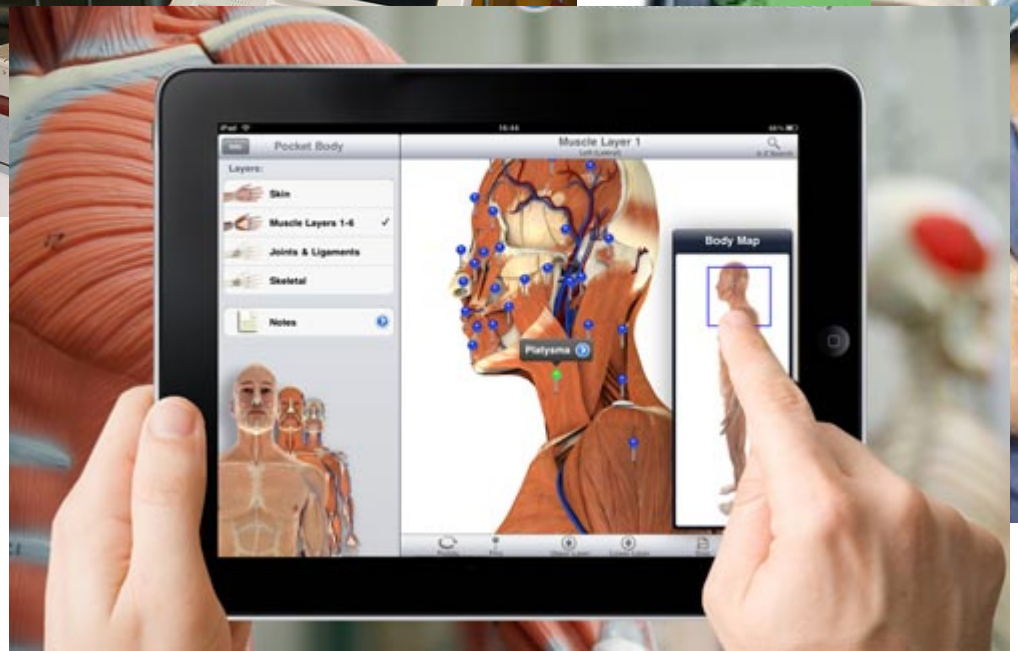
4. Physical support and ubiquity



Electronic Health Records

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- Introduction
- Health Records Today
- Electronic Health Records (EHRs)
- **Other Aspects of EHRs**
- New Challenges: National EHR

4. Other aspects of EHRs

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Other aspects of EHRs

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- Legal aspects of EHR:
  - **Healthcare law** (Spanish regulations):
    - National: Ley General de Sanidad (25/04/1986).
    - National: Autonomía del Paciente y Documentación Ley 41/2002 (14/11/2002).
    - Regional: competencias sanidad transferidas a CCAA.
  - **Norms about Personal Data Protection** (Spanish regulations):
    - Ley Orgánica de Protección de Datos de Carácter Personal (LOPDCP):
      - Ley Orgánica 15/1999 del 13/12/1999
    - Medidas seguridad de ficheros automatizados que contengan datos de carácter personal:
      - Real Decreto 994/1999 del 11/07/1999

Other aspects of EHRs

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- Legal aspects of EHR:
  - **Development of computer related support for medical information** (Spanish regulations):
    - Ley Autonomía Paciente (Ley 41/2002) : allows to record the patient HR in any kind of hardware: paper, computer, etc.
    - LOPDCP (15/1999):
      - Obly to inform the people involved about the existence of the file, its responsible and the goal of this file.

Other aspects of EHRs

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- Legal aspects of the EHR:
  - **Validity** of the EHR:
    - The HR in a paper can be replaced by the EHR: both have the same legal value.
    - Electronic signature has the same legal value than the manuscript signature
      - RD 14/1999 (17/09/1999)
    - EHR as an **evidence**
      - Ley Enjuiciamiento Civil 7/01/2000

      Da valor legal como prueba a *"los medios de reproducción de la palabra, el sonido y la imagen, así como los instrumentos que permiten archivar y conocer o reproducir palabras, datos, cifras y operaciones matemáticas […]"*.

Other Aspects of EHRs

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- Legal aspect of the EHR
  - **Responsibilities** of the EHR:
    - To guarantee the confidenciality of the information:
      - Ámbito penal (ej. Delito simple acceso a datos no autorizados a datos de carácter personal)
      - Civil o patrimonial (ej. Vulneración de confidencialidad constituye un daño moral indemnizable)
      - Administrativo (ej. Régimen de sanciones impuesto por la LOPDCP).

Other Aspects of EHRs

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- Standards HCE:
  - ISO 13606 (CEN UNE 13606): EU standard to facilitate the interchange of EHR extracts.
  - OpenEHR: open standard for administration and storing of clinical information.
  - Related standards:
  - Communication: Eg. HL7, DICOM.
  - Codification: Ej. CIE, SNOMED, LOINC, NIC-NOC.
  - System architecture: Ej. CEN HISA.

Electronic Health Records

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New Challenges of EHRs

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- Project "Digital Clinical History of the National Health Service (Spain)"

Historia Clínica Digital del Servicio Nacional de Salud

http://www.msps.es/profesionales/hcdsns/home.htm

Documentación:

descripción del proyecto HCDSNS

http://www.msc.es/profesionales/hcdsns/contenidoDoc/documentacion.htm

Área de recursos semánticos:

snomed, arquetipos, identificador único, etc. (más adelante)

New Challenges of EHRs

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HCDSNS will contain:

- Clinical report: discharge
- Clinical report: external query
- Clinical report of ERInforme Clínico de Urgencias
- Clinical report of PA
- Clinical report of nurse care.
- Clinical report of image test results
- Clinical report of lab test results
- Clinical report of diagnostic test.
- Clinical report of Minimum Dataset

ELECTRONIC HEALTH RECORDS

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Basic References:

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Scientific Papers:

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- Van der Lei. *Use and abuse of computer stored medical records*. Methods Inf Med, 1991;30(2), 48-50.
- Stanley Reiser. *The clinical record in medicine. Part 2: Reforming content and purpose*. Ann Intern Med 1991;114(11):980-985.
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