

The Electronic Health Record

a clinical introduction

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Dr Dipak Kalra

Clinical Senior Lecturer in Health Informatics

- 10 years as a GP in east London (1986-96)
- 6 years Chair of Medical Audit Advisory Group (1989-95)
- 16 years involvement in GP Computer Systems development (1989-date)
- 14 years European research into Electronic Health Records (1991-date)

Why do we need EHRs ?

- Manage increasingly complex clinical care
- Connect multiple locations of care delivery
- Deliver evidence-based health care
- Reduce errors and inequalities
- Reduce duplication and delay
- Underpin population health and research
- Empower and involve citizens in their health agenda
- (Maybe reduce healthcare costs)

Scale of the problem: on paper

- University Hospital of Heidelberg: 1700 beds
 - creates about 400,000 new medical records per year
 - containing 6.3 million pages
 - requiring 1.7 km of storage
 - (growing at the rate of 1500m per annum)
 - Physicians create over 250,000 reports and 20,000 procedure reports each year
 - service departments create around a million results

1995 Audit Commission Report on Patient Health Records

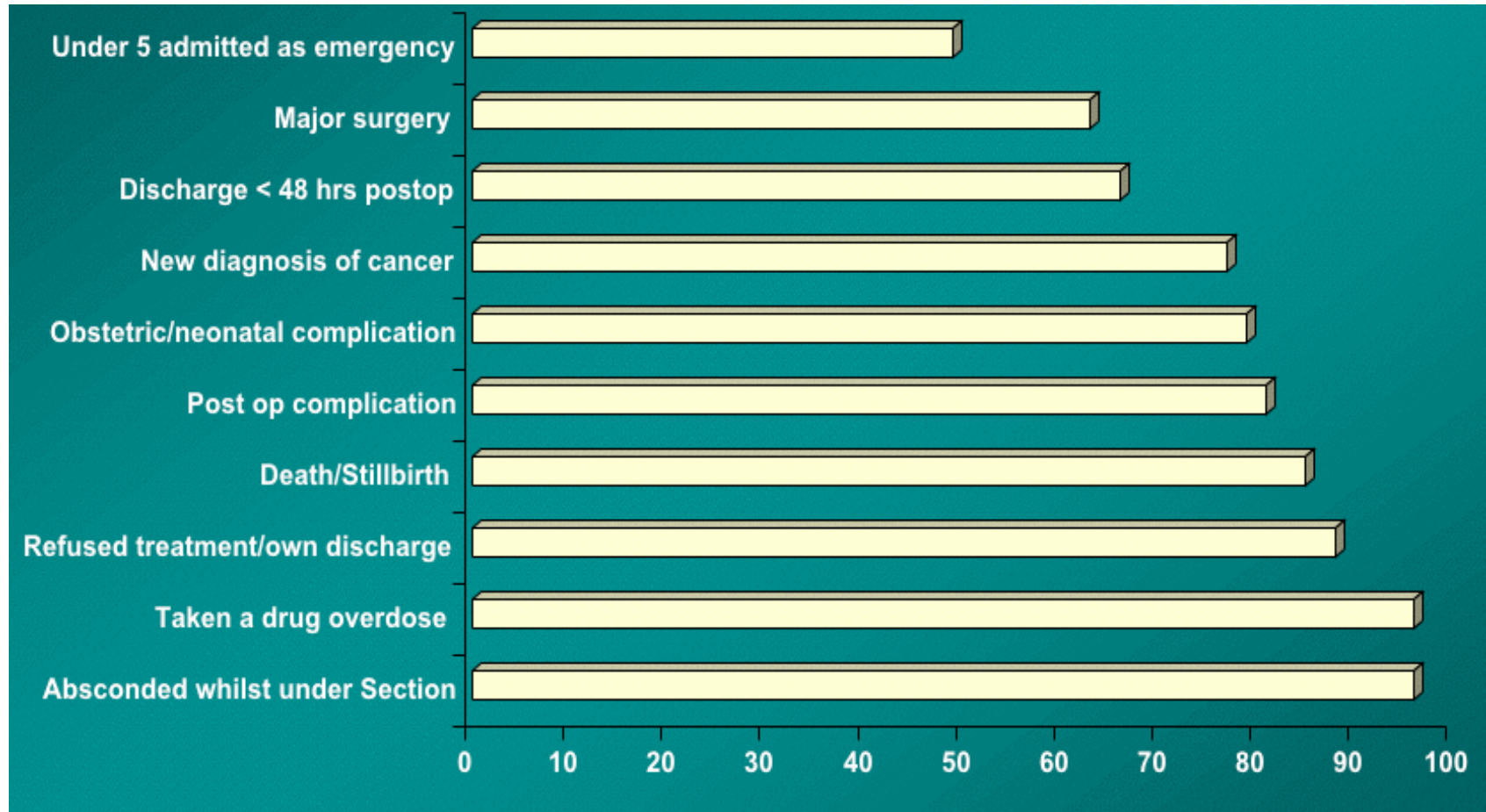
- 36% of case-notes not immediately available
- Multiple records for same patient in 75% of hospitals
- 30% of history sheets inadequate
- 20% of prescriptions illegible
- 40% of handwritten discharge medication sheets illegible

Access to information: the extent of the problem

Clinical Information Item	Requested by physician	Available to physician
Medication	70%	10%
Date of admission or discharge	70%	9%
Care plan	64%	30%
Diagnosis	60%	8%
Current problem list	55%	2%
Prognosis	55%	0%

High risk areas of clinical communication breakdown

Shared care communications survey (Kalra, D. London, 1997)



Percent of GPs reporting problems

Importance of data quality and its availability

- The US Institute of Medicine report "To Err is Human" has estimated that 100,000 US citizens die each year through medical errors
- Medical errors may rank as the eighth leading cause of death in the US, and contribute 4% (\$37.6 billion) to the cost of US healthcare
{Anderson 2000 }

Exploiting good clinical data

- Alerting systems have been shown to save lives “to a remarkable degree” *{Teich and Wrinn 2000}*
- Alerting system examples
 - drug prescription interactions and adverse effects *{Miller, Reichley et al. 1999}, {Rogers, Jain et al. 1999}*
 - alert algorithms for laboratory values, drug interactions and contraindications *{Warner, Miller et al. 1998}*
 - a pager-based alerting system for physicians looking after intensive care patients in a tertiary care hospital *{Shabot, LoBue et al. 2000}*
 - image processing and interpretation of mammograms *{Alberdi, Taylor et al. 2000}*

Requirements of evidence based medicine

- The learned literature has doubled every 10-15 years over the past 300 years;
- In the field of biomedicine 20,000 journals and 17,000 books are produced every year
- Around half of the concepts believed to exist in the world (500,000) are in the medical domain

{Baud, Lovis, et al. 1998}

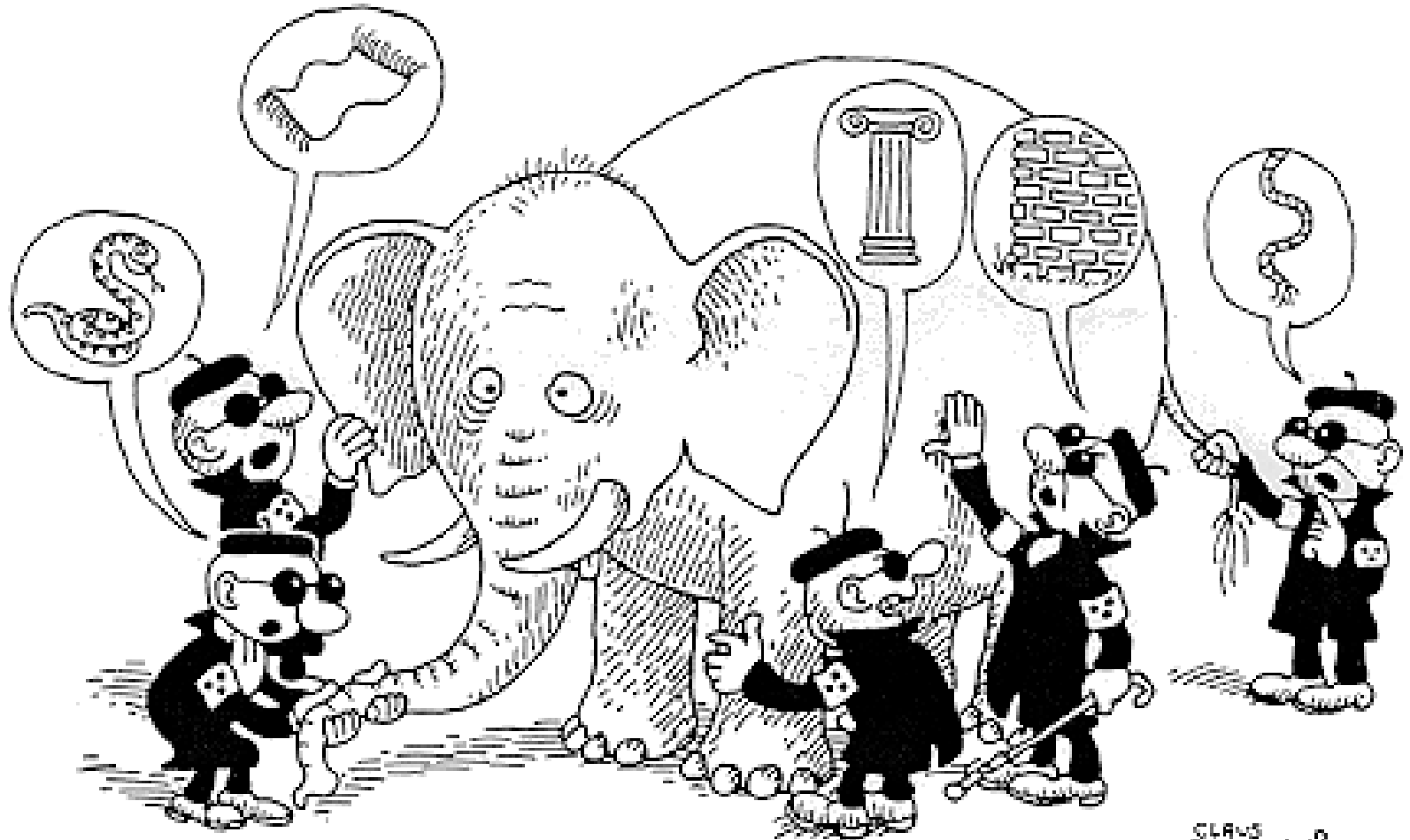
Perceived benefits of the computer

- duplicate data entry is avoided
- data entry templates can be adapted as ideas evolve
- the data can be viewed in many different ways
- data may be accessed from any terminal on a network, and communicated electronically
- it is easier to analyse the data
 - to produce summaries, tables and graphs
 - to use alongside protocols and decision support systems
 - for clinical audit and resource management

It's difficult to get to a clear desk!

- Workstations are too slow and applications too clumsy for real-time use
- Structured templates and term sets are resented by clinicians
 - patient encounters rarely follow a consistent pattern
- Duplication of data entry still occurs
 - existing paper records are usually retained
- There is a lack of agreed standards for the electronic transfer of records between systems

What is an EHR?



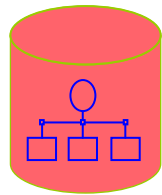
CLAUS
BEJERUM
1987

What makes a good EHR ?

10 quality criteria

1. Comprehensive
2. Faithful
3. Life-long (and beyond)
4. Medico-legally rigorous
5. Educating
6. Supporting diverse cultures and professions
7. Capable of evolution
8. Empowering and respecting
9. Appropriately ubiquitous
10. Capable of interoperability

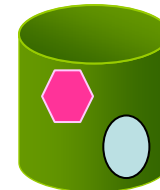
Clinical trials,
functional genomics
and inherited genotype



EHR systems
and servers



Decision support,
knowledge management
and analysis components



Personnel registers,
security services



Mobile devices



Clinical devices,
instruments

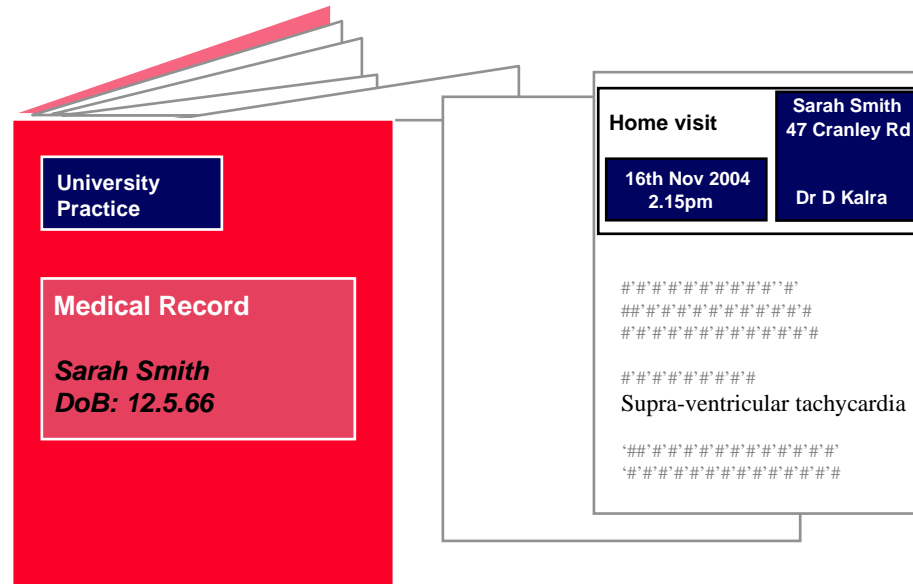


Clinical
applications

An Example Record Entry



An Example Record Entry



An Example Record Entry

Home visit	Sarah Smith 47 Cranley Rd
16th Nov 2004 2.15 pm	Dr D Kalra

#####

Supra-ventricular tachycardia

'#####'
'#####'

has several contexts within a health record

*Compositional
context*



*Ethico-legal
context*



Data value context



*Reasoning
context*



*Care process
context*

*Compositional
context*

*Ethico-legal
context*



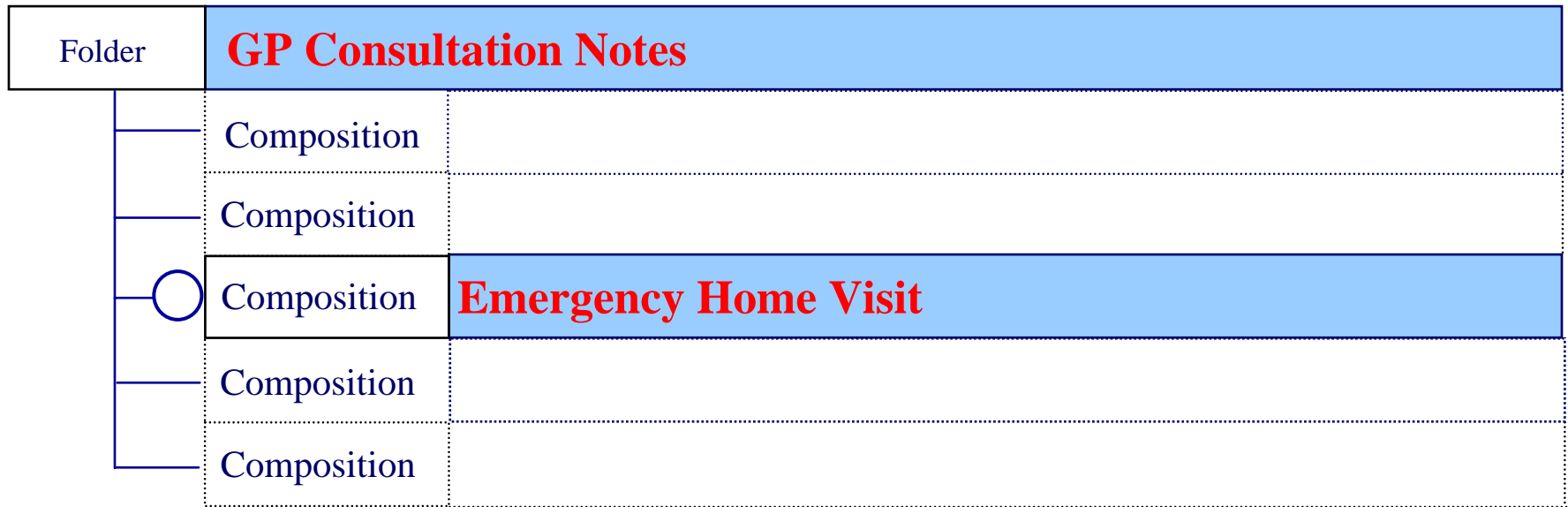
Entry	Diagnosis	Supra-ventricular tachycardia
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Data value context

*Reasoning
context*

*Care process
context*

Compositional context example

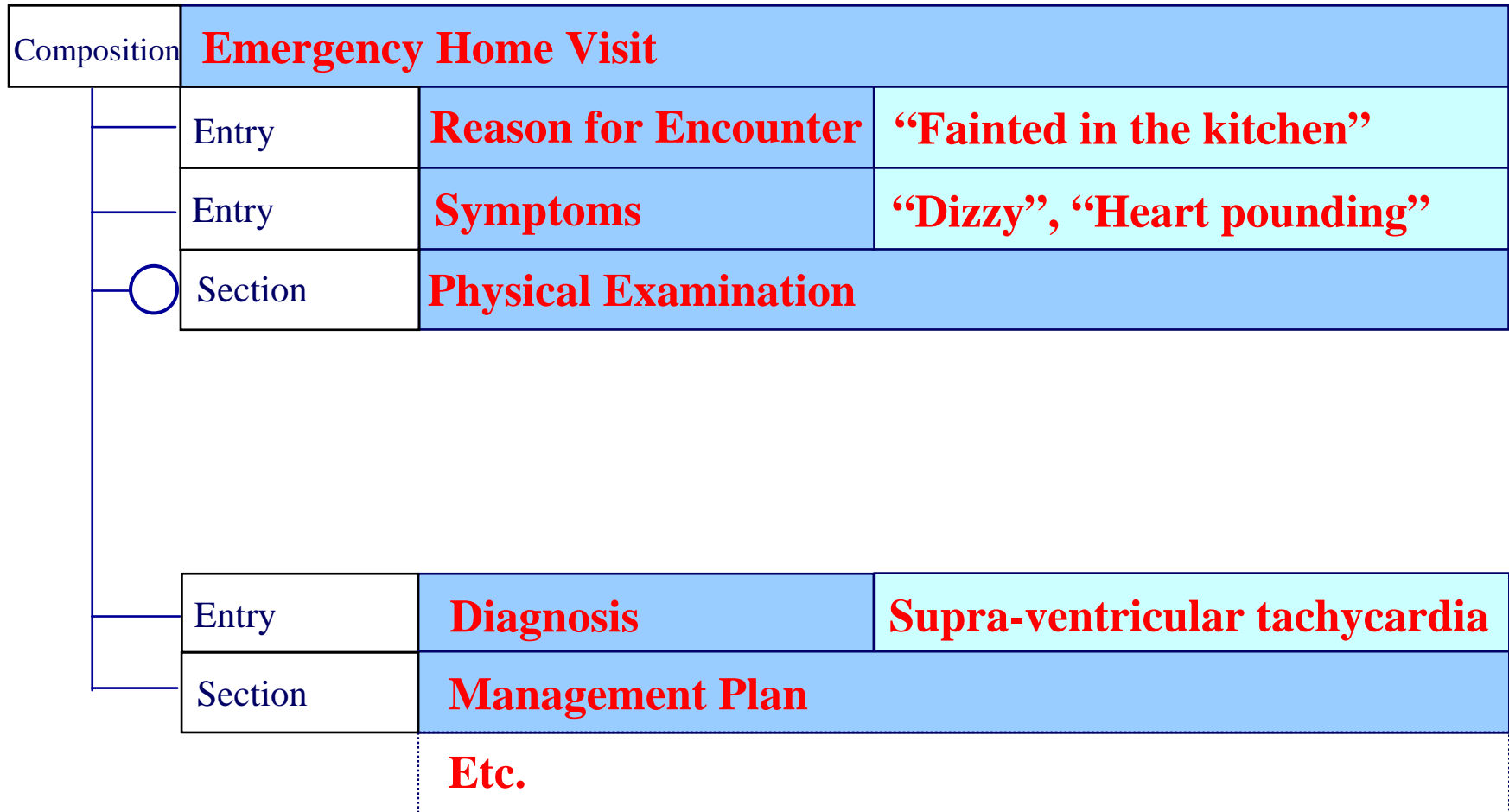


— Aggregation

□ Architecture construct

■ Name

Compositional context example



□ Architecture construct

■ Name

■ Data value

Compositional context example

Composition	Emergency Home Visit		
Entry	Reason for Encounter	“Fainted in the kitchen”	
Entry	Symptoms	“Dizzy”, “Heart pounding”	
Section	Physical Examination		
Cluster	Pulse		
Element	Rate	145 per minute	
Element	Rhythm	Regular	
Entry	Diagnosis	Supra-ventricular tachycardia	
Section	Management Plan		
	Etc.		

□ Architecture construct

■ Name

■ Data value

Compositional context

- Every record entry must be able to have a name which provides a label for each data value
- Record entries can be
 - an element e.g. for *Weight*
 - or a compound e.g. for *Blood pressure*, *Full blood count*
- A formal record structure hierarchy must preserve the way in which entries were originally ordered and grouped by the author
- The record architecture must define the minimum medico-legally acceptable cohort of data from which EHRs must be constructed

*Compositional
context*

*Ethico-legal
context*



Data value context

*Reasoning
context*

*Care process
context*

Data Value context example

Element entry	Diagnosis	Supra-ventricular tachycardia
---------------	------------------	--------------------------------------



Term code = **< G570z >**
Term rubric = **“Supra-ventricular tachycardia”**
Qualifiers = **< >**
Language = **<English>**
Term set = **< READ v 2 >**
Version = **< Release 2.87 >**
Registered with = **<UK NHS Information Authority>**

Data Value context

- Formal representations for all data types
 - including text, quantities, time, persons, multi-media
- Names of term sets, versions and registering agencies
- Natural language used in a recording
- Accuracy, precision and units for quantities
- Normal ranges

*Compositional
context*

*Ethico-legal
context*



Data value context



*Reasoning
context*

*Care process
context*

Reasoning context example

Element entry	Diagnosis	Supra-ventricular tachycardia
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Presence/absence = **< Present >**

Certainty = **< Uncertain >**

Clinical reasoning = ***“Most likely cause of SVT in a woman of this age with a history of thyrotoxicosis”***

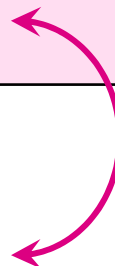
Reasoning context example

Element entry	Diagnosis	Supra-ventricular tachycardia
---------------	------------------	--------------------------------------



Presence/absence = **< Present >**
Certainty = **< Uncertain >**
Severity = **< Severe >**
Clinical Reasoning = ***“ Most likely cause of SVT in a woman of this age with a history of thyrotoxicosis ”***
Bibliographic Ref. = **< BMJ >**

Medical Knowledge Server



Reasoning context

- **Presence / absence**
- **Certainty**
- **Prevailing clinical circumstances**
(e.g. *standing, fasting*)
- **Justification, clinical reasoning**
- **Knowledge reference**
(e.g. *Medline*)

*Compositional
context*

*Ethico-legal
context*



Entry	Diagnosis	Supra-ventricular tachycardia
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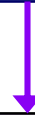
Data value context

*Reasoning
context*

*Care process
context*

Ethico-legal context example

Element entry	Diagnosis	Supra-ventricular tachycardia
---------------	------------------	--------------------------------------



<i>Subject of care =</i>	NHS123456
<i>Composer =</i>	Dr A Austin
<i>Legally responsible HCP =</i>	Dr D Kalra
<i>Healthcare Activity Location =</i>	Patient's home
<i>Observation time =</i>	16 Nov 2004 14.20 GMT
<i>Committer to EHR =</i>	Ms M Jacks
<i>Committal time =</i>	18 Nov 2004 16.27 GMT
<i>Access rights =</i>	Clinical, patient, carers
<i>Version =</i>	Version 2
<i>Reason for revision =</i>	Original saved in wrong patient's EHR
<i>Reference to prev version =</i>	uk.nhs.uclh.xfmhggsy5upoj4dioe0

Ethico-legal context (1)

- **Authorship and responsibilities**
 - who composed the information?
 - who provided it? (e.g. family member)
 - who committed it to the EHR? (e.g. secretary)
 - who was medico-legally responsible? (e.g. consultant)
- **Data subjects**
 - whose record is this? (who is the patient?)
 - about whom is this observation? (e.g. family history)
- **Dates and times**
 - when did the event occur?
 - when did the clinician learn about it?
 - when did it get recorded in the EHR?

Ethico-legal context (2)

- **Version control**
 - is this the original version?
 - if not, when was it changed, by whom, and why?
 - if multiple versions exist, what is the sequence of changes made?
- **Access rights**
 - who should be permitted to access this Entry?
 - who should decide?
 - what about emergency access?

*Compositional
context*

*Ethico-legal
context*

Entry	Diagnosis	Supra-ventricular tachycardia
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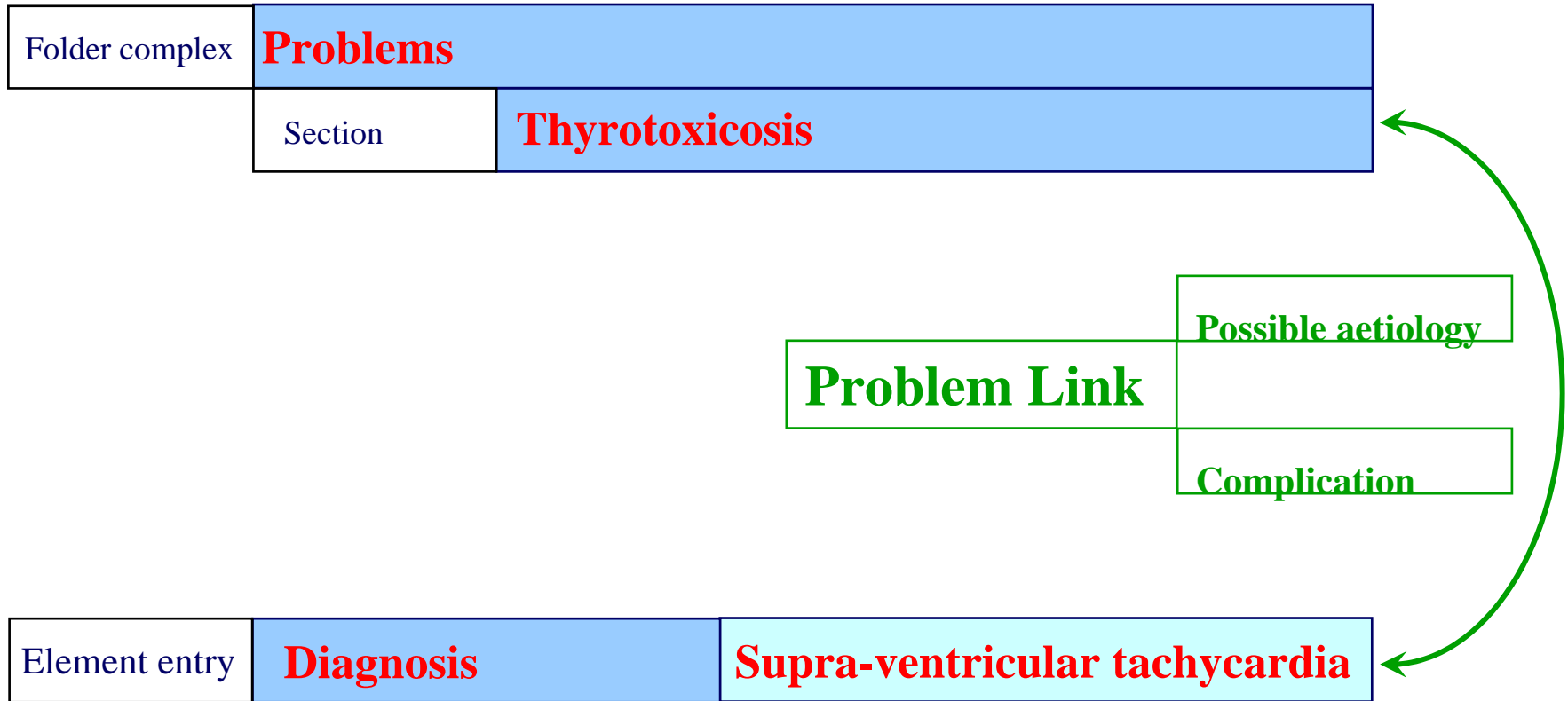
Data value context



*Reasoning
context*

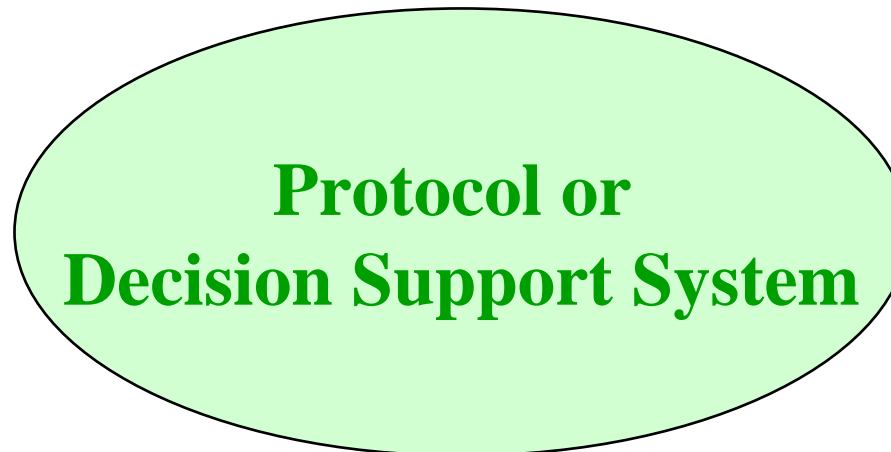
*Care process
context*

Care Process context example



Care Process example

Element entry	Diagnosis	Supra-ventricular tachycardia
Section	Management Plan	
	National Institute recommendations...	



Care Process context

Links and pointers:

- **to other parts of the record**
e.g. cause and effect
request and result
process status
- **to a defined problem**
- **to an episode of care**
- **to a stage in a protocol**
- **to a decision support system**

The Architecture of an Electronic Health Record

must account for all of these contexts:

- faithfully and unambiguously

to enable the record to be:

- comprehensive
- portable
- durable
- ethico-legally acceptable

Aspects of Security

Requirements
for the record
architecture



- Rigorous access rights framework to parts of patient records
- Attributable record entries

Relevant
to both



- Unambiguous identification of patients and users

Required from
an enterprise
information
system



- Authentication of registered users
- Secured networks and telecommunications
- Backup and general protection of the data

Research on EHR interoperability within Europe (1992-2004)

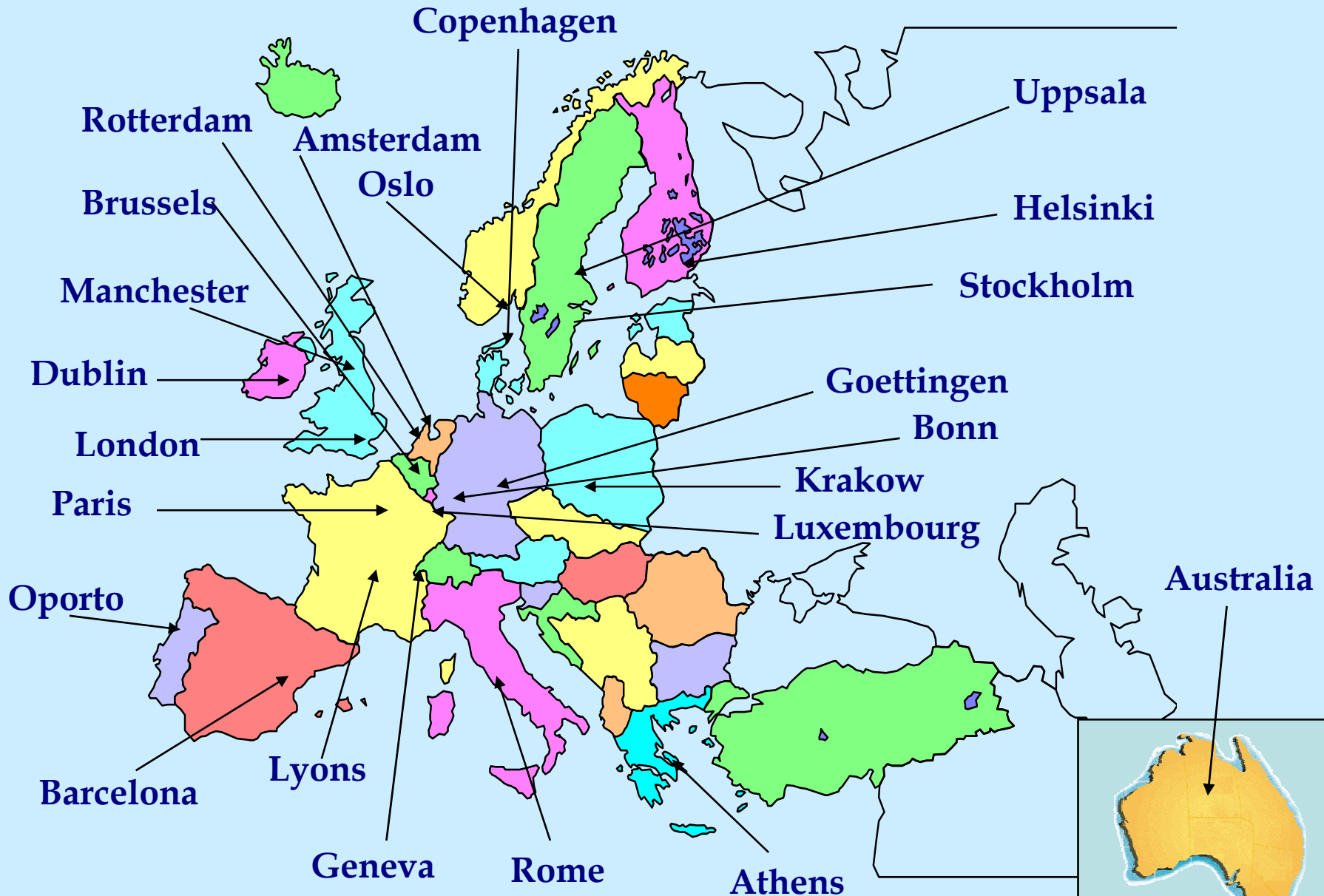
- to provide the faithful, seamless and secure sharing of EHRs
 - derived from diverse clinical databases and record systems
 - within large healthcare organisations, between primary and secondary care
 - across regions and countries
 - to create a physical or logical longitudinal EHR for any patient
 - implemented through Federated Health Record services
- underpinned by rigorous analysis of clinical, technical and medico-legal requirements
 - published internationally, and now reflected in ISO/TS 18308
- evaluated in a range of live demonstrators across Europe and Australia

Example EHR research projects

1991-2005

- GEHR requirements and architecture
- EHCR SupA recommendations to CEN
- Synapses and SynEx federated health record services
- HANSA and its ancestors (RICHE, Nucleus, EDITH)
- InterCare and PICNIC tele-health record systems
- I4C integrated cardiac records, based on ORCA
- Domain specific work: DIABCARD, TELENURSE, MEDICATE
- HARP security and record components
- PROREC - EHR requirements, vendor and user networks
- New research projects in bio-informatics and genomics
- Many other projects....

Contributing EHR demonstrator sites



Realising the EHR

- A new generation of health informatics standards is emerging: EN13606
- Open source reference EHR systems will stimulate confidence in solutions and stimulate the market: *openEHR*

CEN EN 13606: EHR Communications standard

- To produce a rigorous and durable information architecture for communicating the EHR
- in order to support the interoperability of systems and components that need to interact with EHR services
 - as discrete systems or as middleware components
 - to access, transfer, add or modify health record entries
 - via messages or distributed objects (services)
 - preserving clinical meaning
 - protecting confidentiality

The *open*EHR Foundation

- An independent, non-profit community, facilitating the creation and sharing of health records by consumers and clinicians via open-source, standards-based implementations
- Publishes evolving EHR design specifications, strongly underpinned by live clinical demonstrators
- Uses a multi-model approach, including archetypes
- Actively contributing to CEN, ISO and HL7 standards
- Working in partnership with the EuroRec Institute on user and industry liaison and education

www.openehr.org