Family Medicine Informatics and the eMR
the Healthcare Informatics for Research Education and Service (HiRES) project

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http://hiriresearch.wordpress.com/
Healthcare a backwater of technology

• Healthcare remains a paradox of cutting edge medical technology while being an information technology backwater.
• the key is to view hospitalization as a failure rather than something to be optimized.
• emerging Direct Primary Care (DPC) model
Heart rate on cellphone

- 10 million downloads in first year
- Used successfully to diagnose atrial fibrillation in office
What is Informatics
Its not about the bike

- Physicians are more interested in the patient than in the computer
What is Informatics?

- **S**: (n) information science, informatics, information processing, IP (the sciences concerned with gathering, manipulating, storing, retrieving, and classifying recorded information)

  http://wordnetweb.princeton.edu/
What is a Model?

• “Man tries to make for himself in the way that suits him best a simplified and intelligible picture of the world and thus to overcome (sig. understand) the world of experience, for which he tries to some extent to substitute this cosmos (sig. picture) of his.

• This is what the painter, the poet, the speculative philosopher and the natural scientist do, each in his own fashion... one might suppose that there are any number of possible systems... all with an equal amount to be said for them; and this opinion is no doubt correct, theoretically.

• But evolution has shown that at any given moment out of all conceivable constructions one has always proved itself absolutely superior to all the rest.”

• Einstein, A. “The World as I See It” (1931)
What is an EMR?

• an evolving concept defined as a systematic collection of electronic health information about individual patients or populations.

• It is a record in digital format that is capable of being shared across different health care settings, by being embedded in network-connected enterprise-wide information systems.
“computer-based patient record”
CPR

• “…an electronic patient record that resides in a **system** specifically designed to support users through availability of complete and accurate data, practitioner reminders and alerts, clinical decision support systems, links to bodies of medical knowledge, and other aids”

R.S. Dick; E.B. Stein: “The Computer Based Patient Record; An Essential Technology for Health Care”; Institute of Medicine, National Academy of Science 1991
The Computer-based Patient Record: An Essential Technology for Health Care

- The 1991 & 1997 Reports
  - (Tang / Hammond / van Bemmel / van Ginneken / van der Lei)
- A newly conceived record, not a digital version of traditional medical record
- Computer-based -- Put the focus on the record, not the computer
- Data entry by relevant responsible person
eMR Generations
Gartner eMR Generations

- **Generation 1:** The Collector
- **Generation 2:** The Documentor
- **Generation 3:** The Helper
- **Generation 4:** The Colleague
- **Generation 5:** The Mentor

Y-axis: Reduction in Preventable Errors
X-axis: Year
eMR Generations

1st: The Collector - simple systems that provide a site-specific solution for the need to access clinical data which is imported through scanning or other forms of aggregation

2nd: The Documenter - basic systems that clinicians use at the point of care to adequately document rather than merely access clinical data

3rd: The Helper - Systems that include episodic and encounter data and use decision support tools to assist clinicians, functional in at the minimum both ambulatory and inpatient settings

4th: The Partner - Advanced systems that provide more decision support capabilities and that are operational and accessible across the continuum of care, and providing sufficient credibility as to become the patient's legal medical record

5th: The Mentor - Complex and fully integrated systems that include all previous capabilities and that are a main source of decision support in guiding patient care for both clinicians and consumers
Transitioning Phase

• Physicians were taught to have everything memorized

• This is no longer possible
  – Due to the volume of accumulated knowledge
  – The level of performance that is expected
  – Time pressures

• Physicians now encouraged to take advantage of modern technology
Current Thinking vs Future Proofing

• Current EMRs are designed for documentation
• Users think documentation is a chore and should be minimized
• Few users think of potential benefits of a computable record
• Few users ask for features that needed to build a computable record
  – 100 years ago travellers asking for a faster horse
• Vendors listening to uninformed users
• Vendors designing around what the users say they want instead of doing the right thing
We can turn this?
Into this?
Or This?

- 3D visualization linked to SNOMED terminology
Healthcare information becomes visual with Nhumi Visual Health.

Electronic Health Records (EHR) are often too complex for patients and clinicians to find relevant information quickly. Nhumi Visual Health provides the software components to organize and access medical histories intuitively with a 3D model of the human anatomy.
Nhumi Anatomy

Visualize Clinical Data intuitively with

Nhumi Anatomy Plugin
Or is it really this?

“merely automating the form, content and procedures of the current patient records will perpetuate their deficiencies and will be insufficient to meet emerging user needs”

R.S. Dick; E.B. Stein: “The Computer Based Patient Record; An Essential Technology for Health Care”; Institute of Medicine, National Academy of Science 1991
History of eMR
History of eMR

• It has been 30 years since:
  – The first PC based computers were released
  – Physicians were in the first PC user group
  – EMRs were initiated
  – 40 years since man landed on the moon

• Is it time for a giant leap – disruptive change
  – You cannot cross a chiasm with baby steps

• Medicine needs a design renaissance
History of eMR

• A History of Medical Informatics 1950 – 1990
  – M. Collen
• Definition of an information service  Ledley 1960 , pg 84
• Pg 93 The time oriented record
  – James Fries, Stanford 1972
  – was challenged by L Weed
  – Referenced in openEHR  evolution of the record
  – Mayo physician centred to the patient record
• Standard medical record format Burgess Gordon 1970  pg 95  for convenience for manual reference and for computer processing and storage
  – This was not generally accepted at that time
Blois “Information and Medicine”

- Marsden Blois 1984
- Provides a description of the structure of medical information
“An Essential Technology for Health Care”

1st edition:
1987-1991

2nd edition:
1997
Current State

• Unreadable handwritten scrawl
• Idiosyncratic words and abbreviations
• Handwritten prescriptions now not valid in some US states
• Only 1/3 of patients with chronic diseases are getting recommended treatments
• IOM report to Err is Human
• 30+ year of eMR development
• Expectation of better outcomes
Paper vs. Computers

It is hard to believe that this performs better than computer records.
A certified eMR?

Eh Taylor, accordé depuis.
A améliorer ++
Ne reste plus dans la chambre
Séduit en plus?
Séquestre de la confiance.

Ce week-end pour
Moi aussi assez vulnérable
Et allez-vous.

P. allez-vous.
eMR adoption in US 2001 - 2008

NOTES: Any EMR/EHR is a medical or health record system that is either all or partially electronic (excluding systems solely for billing). The 2009 data are preliminary estimates (as shown on dashed lines), based only on the mail survey. Estimates of basic and fully functional systems prior to 2006 could not be computed because some items were not collected in the survey. Starting in 2007, the skip pattern after the all or partial EMR/EHR systems question was removed. Includes nonfederal, office-based physicians. Excludes radiologists, anesthesiologists, and pathologists.

SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey.
eMR Components
eMR in the Exam Room
eMR Benefits
Growth in Complexity of Records

• One line hospital record 100 years ago
• Increased number of patient encounters
  – Patients living longer
• Dramatic increase in the number of diagnostic tests, on multiple media
• More patients seen by multiple providers
Putative Benefits (system view)

• Chronic Disease Management
• Clinical Decision Support
• Practice based population health management
• Multi-morbidity management
• Disease trajectories
• Predictive medicine
• Diseaseome
Meaningful Use is the Foundation for Better Care (patient view)

• Improving the Quality, Safety, and Efficiency of Patient Care
• Engaging Patients and Families
• Improving Care Coordination
• Improving Population and Public Health
Practices with EMRs are Quicker to Identify Patients who would Benefit from Evidence-Informed Interventions

Paper Records ~ 31 hrs

EMR ~ 1.37 hrs

Low confidence review included all eligible patients

High confidence review included all eligible patients

*Canada Health Infoway; the Population Health Management Challenge, key findings and lessons learned 2011*
Driving Total Health with Health IT

• Kaiser
  – Integrated Health Care
    • Easy, excellent, comprehensive
    • Commitment to Prevention
      – Address issues before they become problems
    • Empower the whole person
  – 40% of patients have signed on to My Health Manager  --- 110,000 Biobank DNA samples
  – In person visits dropping, quality increasing
Odds of admission (any cause) were reduced by 27-40% for patients with complex diabetes.

Oregon Health & Science University
Converting research to care

Original research

Variable

Submission

18% Dickersin, 1987

Bibliographic databases

6.0 - 13.0 years Antman, 1992

6.0 - 13.0 years Antman, 1992

Reviews, guidelines, textbook

9.3 years

Patient Care

17 years to apply 14% of research knowledge to patient care!

Negative results

50% Poynard, 1985

Lack of numbers

Inconsistent indexing

Balas EA, Boren SA. Managing clinical knowledge for health care improvement. Yrbk of Med Informatics 2000; 65-70
Information Filtering

- POEMS
- McMaster PLUS Premium Literature Service
- Informatics Challenges for the Impending Patient Information Explosion
  - Home monitoring of patients
Error Reduction

- Generation 1: The Collector
- Generation 2: The Documentor
- Generation 3: The Helper
- Generation 4: The Colleague
- Generation 5: The Mentor

Reduction in Preventable Errors

Year:
- 1993
- 1998
- 2004
- 2008
- 2012+
“Smart Forms” in an Electronic Medical Record

• Concept used at Harvard and the Mass General
• Consider having templates that are updated by the CPG developers
• Consider Infobuttons to provide just in time information to at the point of care
• Next Generation (Next Steps)
  – The Colleague, The Mentor
CAD/DM Smart Form

Smart View: Data Display

Assessment and recommendations generated from rules engine

- Lipids
- Anti-platelet therapy
- Blood pressure
- Glucose control
- Microalbuminuria
- Immunizations
- Smoking
- Weight
- Eye and foot examinations

Assessment

No recent LDL measurement

Patient is on anti-platelet therapy

Blood Pressure is above goal (avg. over last 2 visits 130/80, goal < 130/80)

Patient is due for Pneumovax (older than 65, no record of prior vaccination)

Patient is due for Influenza Vaccine (high risk medical condition)

Patient may be Current Smoker, not thinking of quitting. Last counseled on 10/10/06.

Patient is overweight or obese (BMI 27.1 on 10/31/06, goal < 25)
Secure Clinical Communication and Notification of Results

Automatic Reminders

Summary Flowsheets

Intuitive Chart Summary

Coded Clinical Data

Customizable Desktop
Personalized Care

• Evidence based medicine is based on populations but we deal with individuals
• Most strong evidence is based on strictly defined cases
• Most patients have multiple morbidities
• Genomic information will facilitate personalized care
• **Stratified medicine**
Data on this screen covers diabetes specific history and physical findings. Answers from these questions are used to generate the evidence-based summary report, as well as formulating the recommendations. The blood test results can be left blank, answered with one of the choices on the right.

<table>
<thead>
<tr>
<th>Smoking Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye exam in last 3 months</td>
</tr>
<tr>
<td>Foot exam in last 3 months</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Height</td>
</tr>
<tr>
<td>Waist circumference</td>
</tr>
<tr>
<td>Home glucose monitoring</td>
</tr>
<tr>
<td>Exercise 20min per week</td>
</tr>
<tr>
<td>Neuropathy Symptom</td>
</tr>
</tbody>
</table>

### Neuropathy check

**Objective:** Check annually for symptoms or findings such as peripheral anesthesia or pain, erectile dysfunction or gastrointestinal disturbance.

**Target:** Early detection and treatment.

<table>
<thead>
<tr>
<th>Blood Pressure</th>
<th>Systolic</th>
<th>Diastolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microalbuminuria Present</td>
<td>umol/L</td>
<td>Yes</td>
</tr>
<tr>
<td>Creatinine</td>
<td>umol/L</td>
<td>High</td>
</tr>
<tr>
<td>HbA1c</td>
<td>umol/L</td>
<td>High</td>
</tr>
<tr>
<td>Total Cholesterol</td>
<td>umol/L</td>
<td>High</td>
</tr>
<tr>
<td>HDL</td>
<td>umol/L</td>
<td>High</td>
</tr>
<tr>
<td>LDL</td>
<td>umol/L</td>
<td>High</td>
</tr>
<tr>
<td>TG</td>
<td>umol/L</td>
<td>High</td>
</tr>
</tbody>
</table>
Failure of Systems & Why EMRs are Needed
Push to Specialize

• Five hundred years ago, Leonardo da Vinci could be a painter, engineer, musician, and scientist
• One hundred years ago, it is said that a physician might have reasonably expected to know everything in the field of medicine. [2]
• A typical primary care doctor must stay abreast of approximately 10,000 diseases and syndromes, 3,000 medications, and 1,100 laboratory tests [6]
• A physician in just one specialty, epidemiology, needs 21 hours of study per day just to stay current [7].
100 years of information
Growth of Medical Knowledge

Medical Articles Catalogued Each Year

Total Articles

Year

A Failure of Systems and Processes

Mortality

• “More than 98,000 Americans die and more than one million patients suffer injuries each year as a result of broken health care processes and system failures.” (IOM, 2000; Starfield, 2000);
A Failure of Systems and Processes

Morbidity

• “...little more than half of patients receive known ‘best practice’ treatments for their illnesses and less than half of physician practices use recommended processes for care” (Casalino et al., 2003; McGlynn et al., 2003)
A Failure of Systems and Processes

Waste

“...thirty to forty cents of every dollar spent on health care, or more than a half-trillion dollars per year, is spent on costs associated with “overuse, underuse, misuse, duplication, system failures, unnecessary repetition, poor communication, and inefficiency”

A Failure of Systems and Processes

An opportunity?

“...the cost of the failure to take advantage of the tools, knowledge, and infrastructure that have yielded quality and productivity revolutions in many other sectors of the economy has been enormous.”

Quotes from Charts

• Patient has chest pain if she lies on her left side for over a year
• On the second day the knee was better, and on the third day it disappeared
• The patient has no previous history of suicides
• Patient has left white blood cells at another hospital
• She is numb from her toes down
• The skin was moist and dry
• Patient has two teenage children, but no other abnormalities
• When she fainted, her eyes rolled around the room
How do unexpected consequences occur?

“When I use a word,” Humpty Dumpty said in a rather scornful tone, “it means just what I choose it to mean—neither more nor less.”

“The question is,” said Alice, “whether you can make words mean so many different things.”

“The question is,” said Humpty Dumpty, “which is to be master—that is all.”

“Alice's Adventures in Wonderland”; 1865 Charles Lutwidge Dodgson (aka Lewis Carroll).
eMR Cautions

• Common Problems and Caveates
The dangerous decade

• Enrico Coiera JAMIA November 2011
• There appears no choice but to implement complex ICT on a large, often national, scale
• Our understanding about how to implement and use them safely remains in its infancy
• Clear standards for user interface design, decision support system construction, or clinician training are only slowly emerging
• We are now beginning to appreciate the complex socio-technical construct that is created when ICT is placed in the hands of users in busy clinical environments
State of the Art Listening device
vs
current eMR

How users feel about using current EMRs
Current EMRs

• What the Doctors want?
Designed by Doctors for Doctors

• There have been many attempts to create EMRs by starting with a blank page
• Lack of awareness of the wealth of information that is available from work done over the past 25 years.
• Applications are idiosyncratic, may have some nice features but there are gaps in the information model
User Attitudes

• Show me the numbers
  – Graphing routines are ignored

• Free text is easier to use
  – Octo Barnett -- “There is no free text”
    • You pay for it one way or another

• Prefer to enter blocks of narrative text rather than structured data
  – Unstructured data is very tricky for computers to interpret correctly
eMR Problems

• Koppel 2005  CPOE facilitating Medication Errors
• Han 2005 Unexpected Increased Mortality after Implementation of CPOE
• Conclusion was that the CPOE caused errors
• More accurate conclusion that a poorly designed CPOE & other system issues that caused the errors
Importance of User Interface

• Published papers on errors attributed to computer based systems
  – Illustrate the importance of good interfaces
• Examples of EMRs that facilitate data corruption
• Examples of EMRs that facilitate user error
Graphing

Prescription Timeline

Five problems are manifest here:
- Normal range is not displayed
- Urine hemoglobin is mixed in with blood hemoglobins
- The year is not displayed sometimes
- Some dates are overlapped
- Medications are requested but are not displayed
Truncation Error

- This is an extremely common problem
- The interesting bits are what is usually cut off
ICD Description Error

- Implementation error was found in 3 different EMRs
- Went uncorrected for years

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>And Respiratory System, Antiasthmatics</td>
<td>9757</td>
</tr>
<tr>
<td>And Respiratory System, Antitussives</td>
<td>9754</td>
</tr>
<tr>
<td>And Respiratory System, Expectorants</td>
<td>9755</td>
</tr>
<tr>
<td>D And Respiratory System, Other And Unspecified Drugs Acting On Muscles</td>
<td>9753</td>
</tr>
<tr>
<td>D And Respiratory System, Other And Unspecified Respiratory Drugs</td>
<td>9758</td>
</tr>
<tr>
<td>D And Respiratory System, Oxytocic Agents</td>
<td>9750</td>
</tr>
<tr>
<td>And Respiratory System, Skeletal Muscle Relaxants</td>
<td>9752</td>
</tr>
<tr>
<td>And Respiratory System, Smooth Muscle Relaxants</td>
<td>9751</td>
</tr>
<tr>
<td>And Tissues</td>
<td>238</td>
</tr>
<tr>
<td>And Tissues, Bones And Articular Cartilage</td>
<td>2380</td>
</tr>
<tr>
<td>And Tissues, Breast</td>
<td>2383</td>
</tr>
<tr>
<td>And Tissues, Connective And Other Soft Tissue</td>
<td>2381</td>
</tr>
</tbody>
</table>
Number vs Graph
Florence Nightingale Graph 1874
Foundational Principals of Informatics
Building Blocks of the eMR

- Information Model
- Terminology
- Messages
- Medical Knowledge Reference Material
- Information and process standards for eMR content (http://emrwg.org/)
James Fries requirements 1984

• Record data once so it can be referred to again
• An outside observer should be able to ascertain the reasons why things were done
• Data should be displayed with observations seen in context of the previous, subsequent and related observations
• The Chronic Disease Data Bank: First Principals to Future Directions 1984 J Med Philos
Desiderata
for controlled medical vocabularies

- Content, Content, and Content
- Concept Orientation
- Concept Permanence
- Nonsemantic Concept Identifier
- Polyhierarchy
- Formal Definitions
- Reject "Not Elsewhere Classified"
- Multiple Granularities
- Multiple Consistent Views
- Beyond Medical Concepts: Representing Context
- Evolve Gracefully
- Recognize Redundancy

James Cimino  Desiderata 1998
eMR Related Standards

- ISO 10781  EHR system requirements
- ISO 13606  EHR architecture
- ISO 13940  Requirements for Continuity of Care
- ISO 18308  EHR Functional Requirements
- HL7 for messaging
- openEHR archetypes
- LOINC - lab results  **Logical Observation Identifiers Names and Codes**
- SNOMED for terminology
What is SNOMED CT?

“Systematised Nomenclature of MEDicine Clinical Terms”

A comprehensive controlled clinical terminology
It’s a terminology, not a classification

Has been under development for over 40 years
Roger Cote at Universite de Sherbrooke

It is the clinical terminology system of choice

It is approved for use in Canada
Background

- Chute outlined three functions required in a Terminology System [3]
  - **Aggregate Terminology**: different data formats outputs for user analysis
  - **Reference Terminology**: the format used to store data
  - **Entry Terminology**: the user interface, the terms used to interact with users during data entry process

- **Snomed CT provides functionality in these three layers**

Age of Semantic Medicine

• New technology is enabling the bridging research labs and clinical practice.
• On April 28, 2009 Microsoft announced the release of Amalga Life Sciences, an extension to the data-aggregation class of products for use by scientists and researchers.
• Through this release, Microsoft is offering scalable “data aggregation and liquidity” solutions that link three audiences: patients, providers, and researchers.
• Companies such as Microsoft are building the “pipeline” to allow data and knowledge to flow through a semantically interoperable network of patients, providers, and researchers.
• These types of connectivity efforts hold the promise of effectively instantaneous dissemination of medical knowledge throughout the healthcare system.
• The Healthcare Singularity could be the gateway event to a new Age of Semantic Medicine.
Next Generation
Innovators Prescription

• Disruptive technologies
• Cannot do baby steps to cross a chasm
• Precision Medicine
• The Innovator's Prescription: A Disruptive Solution for Health Care
Office of the National Coordinator
Annual Meeting Nov 2011

• Acceleration and Tipping Points
  – ePrescribing
  – EHR Adoption
  – The Ice has been Broken
  – Consumer e-Health, patient as a co-pilot
    • openEHR
    • Austria where the PHR is the official medical record
    • Walmart and eClinicalWorks
Collaborating with Machines

The majority of human knowledge has been derived from collaborating with machines

- Details of the cosmos
- Details of the atom
- Decoding the genome
- Decoding proteins
- Evolutionary science
- Weather prediction
- The spread of disease
- Biological operations
- Network traffic flows
- The physics of flight
- Power generation
- ++++
Better and Cheaper

• Intuitive Medicine by experts for difficult cases
• Empirical Medicine for chronic care management
• Precision Medicine for where the diagnosis and therapy are known
• "Disruption will involve pushing more of medicine into the precision category, then automating that care to make it better and cheaper,“
ACHIEVING PRECISION MEDICINE & LOWER COST THRU DISRUPTION

- Intuitive Medicine
- Guideline Medicine
- Precision Medicine
- The art of medicine
- Probabilistic Evidence Based Medicine
- molecular diagnostics
- Experimentation & Problem Solving
- Pattern Recognition
- Rules-Based
- Focused Solution Shop
- Process Businesses
- Facilitated-User Networks
- General Hospitals
- Specialized Facilities
- individual disease management
- figuring out what’s wrong
- Chronic Disease Management
- Procedures after a definitive diagnosis
- value chains
Good Solutions

• UK – Microsoft CUI Common User Interface
  – http://www.cui.nhs.uk/Pages/NHSCommonUserInterface.aspx
  – http://www.mscui.net/
    • Could link to this website and do a demo of some nice things like graphing of lab results. Need Silverlight

Graphs
CUI Graphing Controls

1. Allow the user to change the size of the vertical axis.
2. Horizontal Slider for Period (time window).
3. Have side panel to show visit note or reports as the date cursor goes by.
Info Vis

• Human Computer Interface  HCI
• Very advanced and sophisticated user interfaces and graphics
• Not seen in EMRs
• Widgets to enhance the user experience
  – Direct manipulation interface design
  – Zooming
  – Sliders
LifeLines for Visualizing Patient Records
Visualisation of a “Chronicle”

infiltrating ductal carcinoma left breast

Recurrence

RADIO

CHEMO

TAMOXIFEN

ARIMIDEX

Staging CT

Nodes
Liver
Spleen
Kidney
Bone

T1>N1>M0

?Stage IIA

T1
N3c
M0

Stage IIIc

T1>N3c
M1

Stage IV

Thy-Mors Hospital Denmark 2009

Thy-Mors

IBM Ontology
Consumer Health

• Home Monitoring
  – Weight, ECG, movement, symptoms, images

• Apps used by patients
  – Disruptive technology
  – 10 million downloads of iPhone app in 1 year
DxPlain Demo
The End
Stratified Medicine

• **Stratified medicine** is the management of a group of patients with shared biological characteristics by using molecular **diagnostic testing** to select the best **therapy** in order to achieve the best possible medicinal outcome for that group

• **Personalized medicine** is the goal