Bio-Medical Computing (6.872/HST.950)

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+ guest lecturers

http://stellar.mit.edu/S/course/6/fa06/6.872/
Tue, Thu 2:30-4:00pm, 26-328

Why Keep Records?
• Basis for historical record
• Communication among providers
• Anticipate future health problems
• Record standard preventive measures
• Identify deviations from the expected
• Legal record
• Basis for clinical research

Who Keeps Records?
• Doctor
• Nurse
• Office staff, admissions
• Administrator
• physical therapist
• lab personnel
• radiologist
• pharmacist
• patient

Forms of Clinical Data
• Numerical Measurements
  – Lab data
  – Bedside measurements
  – Home instrumentation
• Recorded signals (e.g., ECG, EEG, EMG)
• Images (X-ray, MRI, CAT, Ultrasound, Pathology, …)
• Genes (SNPs, expression arrays, pedigrees, …)
• Coded (?) discrete data
  – Family history
  – Patient’s medical history
  – Current complaint
  – Symptoms (patient)
  – Signs (doc)
  – Physical examination
  – Medications
• Narrative text
  – Doctor’s, nurse’s notes
  – Discharge summaries
  – Referring letters

Organization of Data
• Doctor’s journal (traditional)
• Time order of collection, per patient (Mayo)
• Source of data
• Problem-Oriented Medical Record (POMR) (L. Weed, 1969)
  – Notes organized by problems
  – SOAP: subjective, objective, assessment, plans

POMR

Data Base
Problem List
Plans
(by problem)
Progress Notes
(by problem)

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The Data Base

- Identifying information (name, age, sex, race, religion, insurance info, etc.)
- Patient profile (occupation, education, marital status, children, hobbies, worries, moods, sleep patterns, habits, etc.)
- Medical history
  - Chief complaints
  - History of present illness
  - Review of systems
  - Family history
  - Medications
- Physical examination
- Laboratory data and physiologic tests (complete blood count, electrocardiogram, chest x-ray, creatinine, urinalysis, vital capacity, tonometry, etc.)

The Problem List

- "those features in the patient’s psychobiological makeup that require continuing attention"
  - Social history
  - Risk factors
  - Symptoms
  - Physical findings
  - Lab tests
- Causally organized; e.g., GI bleeding caused by duodenal ulcer appears under the ulcer

Example Problem List

<table>
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<tr>
<th>No</th>
<th>Active</th>
<th>Date</th>
<th>Inactive</th>
<th>Date</th>
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<tbody>
<tr>
<td>1</td>
<td>Hypertension</td>
<td>1953</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Recurrent bronchitis</td>
<td>1958</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Penicillin allergy</td>
<td>1958</td>
<td></td>
<td></td>
</tr>
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<td>4</td>
<td>Gallstones</td>
<td>Oct 1972</td>
<td>Cholecystectomy</td>
<td>Mar 1973</td>
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<td>5</td>
<td>Arthritis</td>
<td>Mar 1973</td>
<td>#9</td>
<td>June 1973</td>
</tr>
<tr>
<td>6</td>
<td>Proteinuria</td>
<td>Apr 1973</td>
<td>#9</td>
<td>June 1973</td>
</tr>
<tr>
<td>7</td>
<td>SLE</td>
<td>June</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Problem-Related Plans

- Diagnostic: lab tests, radiology studies, consultations, continued observations, …
- Therapeutic: medications, diet, psychotherapy, surgery, …
- Patient education: instruction in self-care, about goals of therapy, prognosis, …

Plans per problem

1. Diarrhea
   Dx:
   - stool for occult blood, culture, ova, and parasites, microscopic fat; and muscle fibers
   - Sigmoidoscopy
   - Barium enema if persistent
   Rx: Avoid foods that exacerbate
   Ed: Informed that more info is needed to make a diagnosis, will aim for symptomatic therapy for now.

2. Pyuria
   Dx:
   - BUN
   - Repeat urinalysis
   - Urine culture

3. Obesity
   Rx: 1500 kcal diet, Weight Watchers
Progress Notes

- Subjective: interval history, adherence to program
- Objective: physical findings, reports of lab, x-ray, other tests
- Assessment: Appraisal of progress, interpretation of new findings, etc.
- Plan: Dx, Rx, Ed.

Example SOAP Note

#3 RHD with mitral stenosis
S: 2 flight dyspnea, mild fatigue. No orthopnea, hemoptysis, ankle edema. Child has strep throat.
O: BP 120/70. P 78 regular. Neck veins normal, lungs clear. Grade iii diastolic rumble, wide opening snap, P₂ slightly ↑
P: Dx: Cardiac fluoroscopy
Rx: Continue chlorothiazide and penicillin V 250mg b.i.d.—2 weeks
Ed: Reinstructed about antibiotic coverage for tooth extractions, sched. for next month. (Will contact oral surgeon.)

POMR characteristics

- Augment with data flow sheets
- Importance of clinical judgment
- Benefits:
  - Communication among team members, explicitness
  - Education and audit
  - Clinical research

POMR evidence

- Difficult adoption
- Some duplication
- Some doctors liked it
- Paper-based POMR slow, computer-based maybe faster
- Demand-oriented MR: by time, by source, by problem, etc. Dynamic arrangement.

Mayo experience

- Paper records, mostly
- Pneumatic tube delivery, therefore limited size
- Formal procedures for reaping and organizing records at discharge
- Comprehensive index

The Computer-based Patient Record

- Made strong case for CPR
- Recommended CPRI (Institute), but it never caught on
- Today’s standards grow more out of communication standards: HL7 (labs) and DICOM (digital images)
**Paper record: Strengths**

- Familiar; low training time
- Portable to point of care
- No downtime
- Flexibility; easy to record subjective data
- Browsing and scanning
  - Find information by unanticipated characteristics (e.g., Dr. Jones’ handwriting)

**Paper record: Weaknesses**

- Content: missing, illegible, inaccurate
  - E.g., one hospital study: 11% of tests were repeats to replace lost information
  - Too thick (1.5 lbs avg.)
  - Fail to capture rationale
  - Incomprehensible to patients and families

**Sample paper record defects**

- 75% of face sheets had no discharge disposition, 48% no principal Dx
- Agreement between encounter (witnessed) and record: 29% med hx, 66% Rx, 71% info re current illness, 72% tests, 73% impression/Dx, 92% chief complaint
- 20.8% of Medicare discharges coded incorrectly (DRG inflation)

**More paper record defects**

- Unavailable at up to 30% of patient visits
  - Two clinic visits in a day
  - Docs keep records in their office
  - Failure to deliver
  - Misfiled in file room
- Discontinuity across institutions
  - In/outpatient records separate

**Ethnographic Design**

- Xerox PARC analysis of office work
  - Sociologists, Anthropologists, Engineers
  - Much of work is
    - communication,
    - assignment of responsibilities,
    - problem solving

**Medicine is an Information Industry**

- 35-39% of hospital operating costs due to professional and patient communications
- Physicians spend 38%, nurses 50% of their time charting
- Exponential growth of medical knowledge and literature
### Individual Users of Patient Records

- **Providers**
  - Chaplains
  - Dental hygienists
  - Dentists
  - Dietitians
  - Lab technicains
  - Nurses
  - Occupational therapists
  - Optometrists
  - Pharmacists
  - Physical Therapists
  - Physicians
  - Physician assistants
  - Psychologists
  - Radiology technologists
  - Respiratory therapists
  - Social workers

- **Management**
  - Administrators
  - Financial managers and accountants
  - Quality assurance managers
  - Records professionals
  - Risk managers
  - Unit clerks
  - Utilization review managers

- **Reimbursement**
  - Benefit managers
  - Insurers (Fed, State, private)

- **Other**
  - Accreditors
  - Gov’t policymakers, legislators
  - Lawyers
  - Health care researchers, clinical investigators
  - Health Science journalists and editors
  - Patients, families

### Institutional Users of Patient Record

- **Healthcare Delivery**
  - Ambulances, associations, networks, systems of providers
  - Ambulatory surgery centers
  - Dentist offices (blood, tissue, organs)
  - HMO’s
  - Home care agencies
  - Hospices
  - Hospitals
  - Nursing homes
  - PPO’s
  - Physician offices, group practices
  - Psychiatric facilities
  - Public Health Departments
  - Substance abuse programs

- **Management and Review**
  - Medicaid peer review organizations
  - Quality assurance companies
  - Risk management companies
  - Utilization review/management comp.,

- **Reimbursement**
  - Business Health coalitions
  - Employers
  - Insurers

- **Research**
  - Disease registries
  - Health data organizations
  - Health care technology developers and manufacturers
  - Health Care Centers

- **Education**
  - Allied health professional schools
  - Medical, nursing, public health schools

- **Accreditation**
  - Accreditation organizations
  - Inst. licensure agencies
  - Prof. licensure agencies

- **Policy making**
  - Fed, State, Local gov’t agencies

### Primary Uses of Patient Record

- **Patient care delivery (Patient)**
  - Document diagnosis
  - Exhibit patient’s condition
  - Document patient’s care
  - Prepare medical records
  - Discharge summary

- **Patient care delivery (Provider)**
  - Foster continuity of care
  - Describe diseases and causes
  - Support decision-making about Rx
  - Assess and manage risk
  - Facilitate care via
  - Assess and manage risk
  - Rx
  - Support decision making about
  - Describe diseases and causes
  - Foster continuity of care
  - Verify billing
  - Self-manage care
  - Constitute proof of identity
  - Document services received

### Secondary Uses of Patient Record

- **Education**
  - Document health care professional experience
  - Prepare conferences and presentations
  - Teach students

- **Regulation**
  - Evidence in litigation
  - Foster postmarketing surveillance
  - Assess compliance with standards
  - Accredit professionals and hospitals

- **Policy**
  - Allocate resources
  - Conduct strategic planning
  - Monitor public health

### User Requirements

- **Record Content**
  - Uniform core data elements
  - Standardized coding systems and formats
  - Common data dictionary
  - Information on outcomes of care and functional status

- **Record Format**
  - “Front-page” problem list
  - Ability to “flip through” the record
  - Integrated among disciplines and sites of care

- **System Performance**
  - Rapid retrieval
  - 24/7
  - Available @ convenient places
  - Easy data input

- **Linkages**
  - To other info systems (e.g., radiology, lab)
  - Transferability of information among specialties and sites
  - With relevant literature
  - Other registries and institutional databases
  - To records of other family members
  - E-billing

- **Training and Implementation**
  - Minimal training required
  - Graduated implementation

- **Intelligence**
  - Decision support
  - Clinician reminders
  - “Alarm” systems, customized

- **Reporting**
  - “Derived documents”, e.g., insurance forms
  - Easily customized output, UI
  - Standard clinical reports, e.g., discharge summary
  - Custom and ad hoc reports
  - Trend reports and graphics

- **Control and Access**
  - Easy patient access
  - Safeguards of confidentiality
Why is this hard?

- Characterize edema:
  - Where?
  - When?
  - How often?
  - Temporal variation?
  - Severity
  - Symmetry
  - What other characteristics?

- Uncertainties in all of the above

- Thousand diseases, syndromes, clinical states
- Few thousand symptoms, signs, observables
- Few thousand specific lab tests
- Thousands of meds, variations, combinations, routes, dosage schedules, …
- ?? Treatments

Not just database, knowledge representation

- "Sometime before his 5th birthday, Johnny had scarlet fever, which caused changes in his heart sounds."
- \( <S> \) WEAKNESS PROXIMAL ONLY
- \( \text{EDEMA with} \)
  - LOCATION = FACIAL or PERI-ORBITAL, PAINFULNESS = not PAINFUL, SYMMETRY = not ASYMMETRICAL, ERYTHEMA = not ERYTHEMATOUS"

Inadequate Coding Systems

- Low degree of refinement
  - E.g., ICD-9’s categories for Chronic Bronchitis
    - Simple
    - Mucopurulent
    - Obstructive
    - Other
    - Unspecified
- Poor coverage of symptoms
- Difficulty of automatic coding
  - Gabrieli’s 10M-phrase thesaurus

Current Status of EMR

- Fully computerized in many hospitals
  - Labs, pharmacy, billing
- Some computerization
  - Visit histories, discharge summaries, vaccination records, emergency dept notes, pathology & radiology notes
- Little computerization
  - Anything outside hospitals & large clinics
  - History, physical, plans, rationale, …

Current Ideas

- Improved Coding
- Data Capture
  - Dictation to text, or speech understanding
  - Text to meaningful code extraction
  - Comprehensive instrumentation
  - Capture at point of generation
- Integration to Workflow
  - Direct physician order entry, protocols, expert systems
- "Aware" environments

Standards: HL7

- HL7, v2.x
  - Messaging standard for communicating clinical data
  - Used in reporting labs, tying together departmental systems, (experiments in) data integration
  - No commitment to storage structures
- HL7, v3
  - Clinical Document Architecture, Reference Implementation Model
    - Participation
    - Role
    - Entity (LivingSubject, Place, Organization, Device, Material)
    - Act-Relationship
Other Standards

• DICOM -- Images
• Coding Standards for clinical content (next class)
• ANSI X.12 messages for EDI
• Medicare (CMS) forms
  – Patient care reimbursement (various settings)
  – Institutional status, finances, regulation compliance, …
• CCR: Continuity of Care Record (ASTM & Mass Med)
  – "organize and make transportable a set of basic patient information consisting of the most relevant and timely facts about a patient’s condition"
    • patient and provider information,
    • insurance information,
    • patient’s health status (e.g., allergies, medications, vital signs, diagnoses, recent procedures),
    • recent care provided, as well as recommendations for future care (care plan)
    • the reason for referral or transfer

A Real Clinical Database

• Clinicians’ Workstation (late 1980’s Hypercard interface to CHB’s Oracle repository)
• Scrubbed (de-identified) data on 300 patients, no disasters since 1996 ;-)
• http://gray.csail.mit.edu/