

Department of Medicine  
HONG KONG University  
5<sup>TH</sup> MAY 2008  
HONG KONG

"Biomedical Informatics"

President Australian College of Health Informatics  
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97868173

1970s-1990s

Early developments

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**DEFINITIONS:**

1. **Communication of health care** -requires the availability of an adequate medical record and the **current paper record** is simply unable to meet the needs of modern health care systems.

2. **Medical practice** is medical decision making and information management is care.

Sherriff & Perreault L. Medical Informatics-Computer Applications in Health Care. 1990/2006

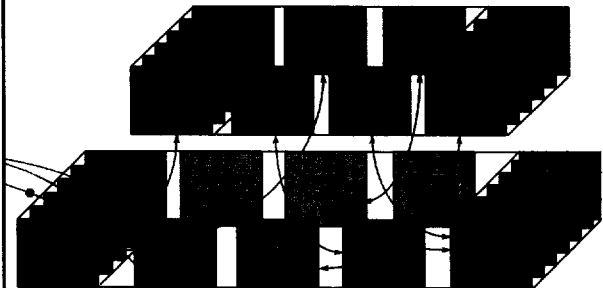
3. **"The computer-based patient record. An essential technology for health care."**

Institute Of Medicine. National Academy Press. National Academy of Sciences. 1991.

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*Overview of patient-oriented information systems that may be found in a clinical environment. J.Van Bemmel.MEDINFO.Seoul 1998*

Clinical Support Systems-Hospital focus



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Clinical Departmental Systems

*COMPUTER-GENERATED REMINDERS, THE QUALITY OF CARE AND THE NON-PERFECTABILITY OF MAN. McDonald CJ. N Engl. J Med. 1976, 295:1351-5*

"..the amount of data presented to the physician per unit time is more than he can process without error. The computer **augments** the physician's capabilities and thereby reduces his error rate....It is very likely that the physicians in these studies were **simply unable to detect all the multitudinous conditions specified by the standards.**"

	Reminder	No reminder
Order recommended test	36%	11%
Change drug order	28%	13%

Percent of times Clinicians responded to protocol action.

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**SUMMARISATION**

**"Discharge summaries are intended to transfer important clinical information from inpatient to outpatient settings and between hospital admissions."**

1. Communication of health care is maintained using a summary patient format in the ambulatory setting.

Fries. J. Alternatives in medical record formats. Medical care. 1974;12:871-881

2. Summary patient record "can serve as the sole source of clinical information in a substantial number of OP follow-up encounters in a medical subspecialty clinic without deterioration in the communication of clinical information",

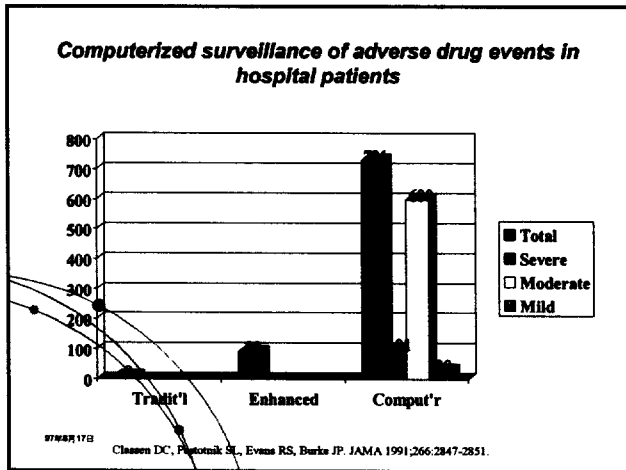
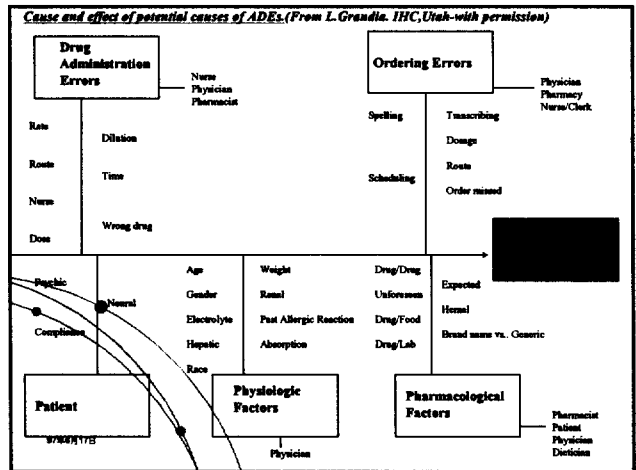
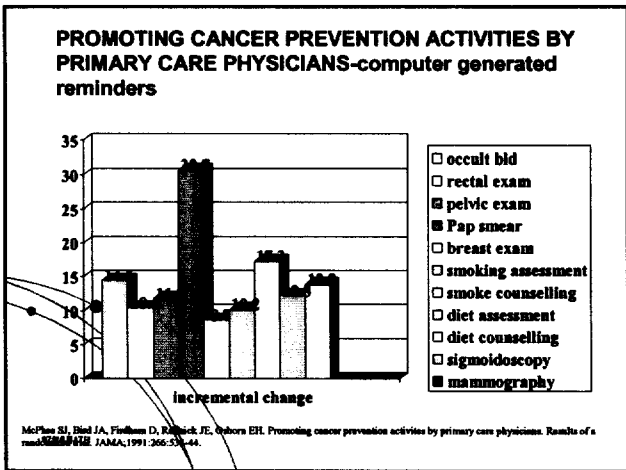
- information accessible is four times faster

• contains up to four times more information

Whiting, O'Keefe QW, Simborg DW, Epstein WV, Medical Care 1980;18:842-852

3. Tabulated results allow physicians to better predict future trends in results.

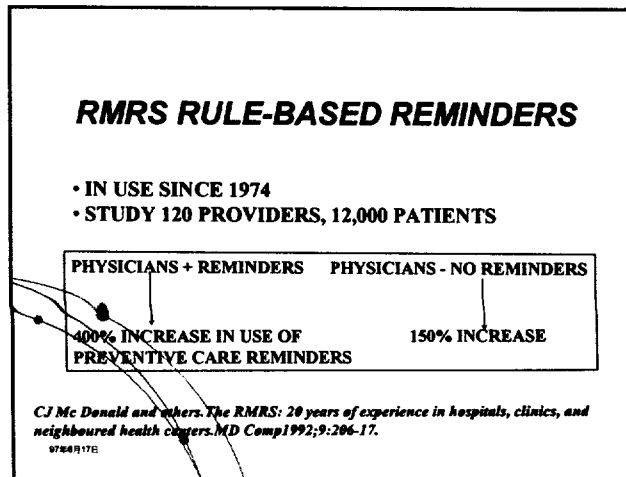
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### ADVERSE EVENTS -IDENTIFICATION AND PREVENTION

“Most hospitals rely on spontaneous voluntary reporting to identify adverse events, but this method *overlooks more than 90%* of adverse events detected by other methods.....*Retrospective chart review* improves the rate of adverse event detection but is *expensive and does not facilitate prevention.*”

Potential identifiability and preventability of adverse events using information systems. Bates et al J Am Med Informatics Assoc. 1994;1:404-411



- ### CCDSS TOOLS ESSENTIAL FOR ANY EMR
1. ALERTING
  2. REMINDING
  2. INTERPRETATION
  3. ASSISTING
  4. CRITIQUING
  5. DIAGNOSING
  6. MANAGING
- [See examples in later slides]
- Pryor TA, Clayton PD. Decision support systems for clinical medicine. SCAMC. 1991.

Importance of Patient owning their record. L. Weed. UVIC. 1989

Patients do not specialize, and they or their families are in charge of all the relevant variables 24 hours a day, every day. They must be given the right tools to work with. They are the most neglected source of better quality and savings in the whole health care system.

After all:

They are highly motivated, and if they are not, nothing works in the long run anyway.

They do not charge. They even pay to help.

There is one for every member of the population.

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## ELECTRONIC MEDICAL RECORD

"The computer-based patient record. An essential technology for health care."

Institute Of Medicine

National Academy Press, National Academy of Sciences. 1991.

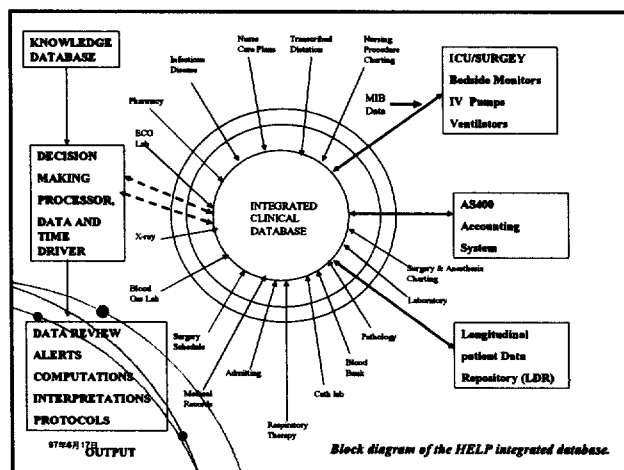
An essential technology for health care

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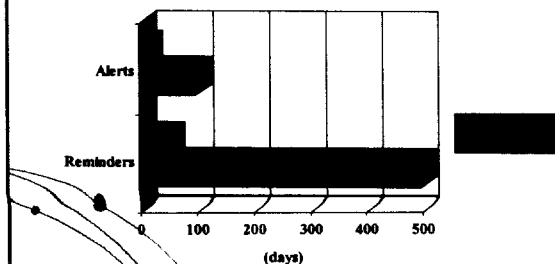
1990s-2000

The Internet era

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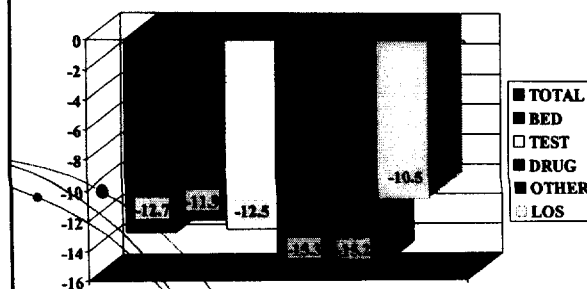
## Clinical Response Time



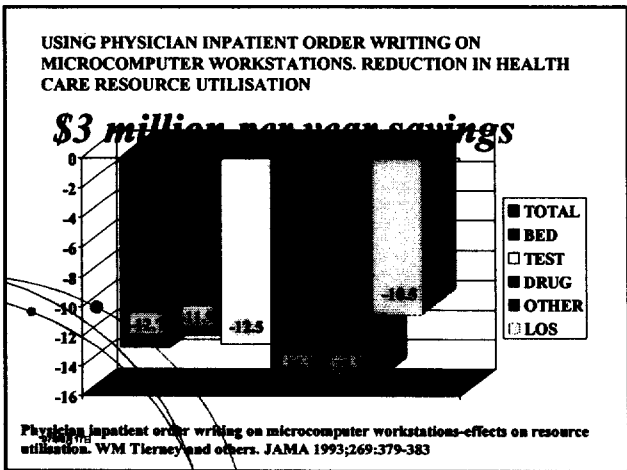
Safran C, and others. Guidelines for the management of HIV infection in a computer-based medical record. *The Lancet* 1995;346:341-46.

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## USING PHYSICIAN INPATIENT ORDER WRITING ON MICROCOMPUTER WORKSTATIONS. REDUCTION IN HEALTH CARE RESOURCE UTILISATION



Physician inpatient order writing on microcomputer workstations-effects on resource utilisation. WM Tierney and others. *JAMA* 1993;269:379-383



### Intermountain Health Care, Salt Lake City, Utah, USA

#### STUDY DESIGN

- Computer-based EMR system
- Patients discharged January 1, 1988 to December 31, 1994
- 162,196 patients
- Goal: to determine clinical and financial outcomes of the antibiotic practice guidelines implemented through the computer system

*Pestotnik, S. L., Classen, D. C., Evans, R. S., Burke, J. P. Implementing antibiotic practice guidelines through computer-assisted decision support: clinical and financial outcomes. Ann Intern Med 1996 May 15*

### Intermountain Health Care, Salt Lake City, Utah, USA

Overall antibiotic use:	decreased 22.8%
Mortality rates:	decreased from 3.65% to 2.65%
Antibiotic-associated ADE:	decreased 30%
Antibiotic resistance:	remained STABLE
Appropriately timed preoperative antibiotics:	40% to 99.1%
Antibiotic costs per treated patient:	decreased \$122.66 to \$51.90
Acquisition costs for antibiotics:	fell 24.8% to 12.9% (\$987,547) to (\$612,500)

Our case-mix index which measures patient acuity levels **INCREASED** during this period, meaning we were treating sicker and sicker patients while better utilizing the delivery of antibiotics.

*Pestotnik, S. L., Classen, D. C., Evans, R. S., Burke, J. P. Implementing antibiotic practice guidelines through computer-assisted decision support: clinical and financial outcomes. Ann Intern Med 1996 May 15*

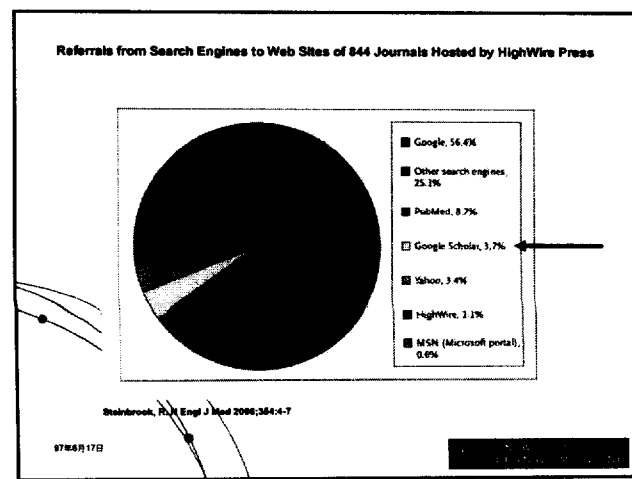
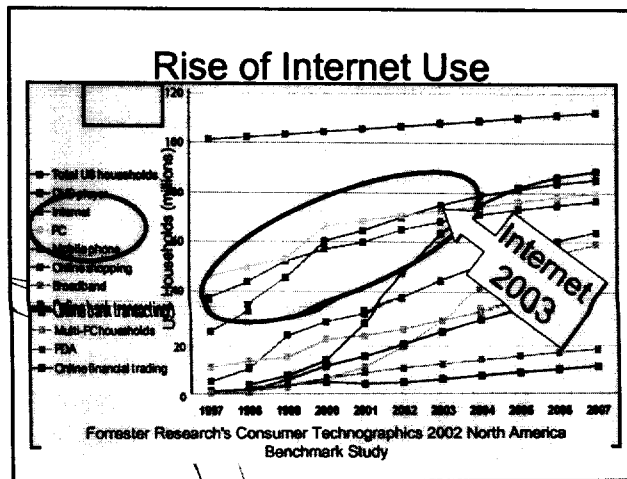
### The Regenstrief Medical Record System. IJMI 54 (1999)

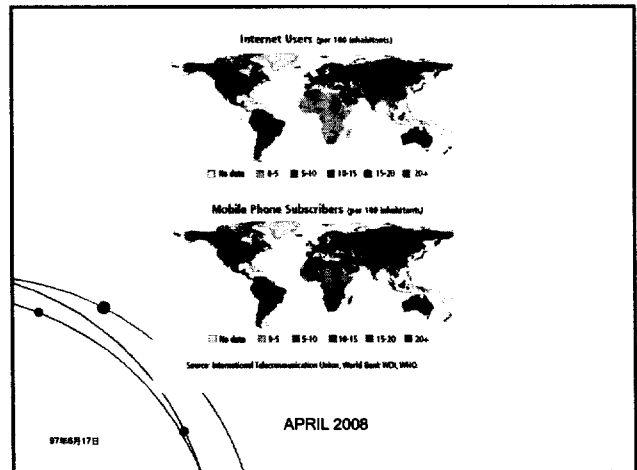
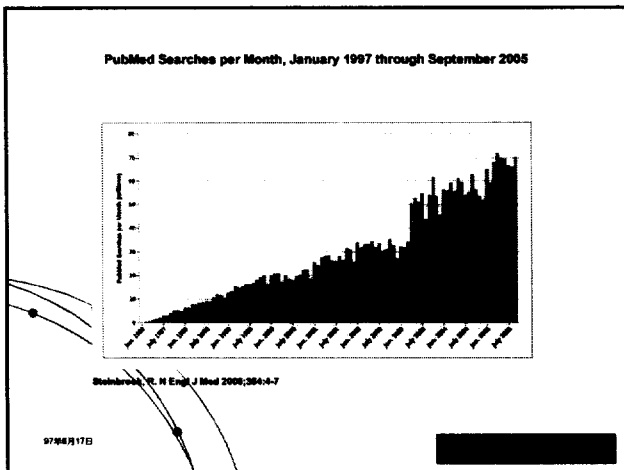
Retrieval times-Fast (blink times)  
Data and information-Comprehensive  
Data storage- Long-term-lifelong  
Data applications-Introspective of total database  
Data storage-

- 200 million coded observations
- 3.25 million narrative reports
- 15 million prescriptions
- 212,000 ECG tracings
- More than 1.3 million patients

Access-

- 1300 medical nurses
- 1000 physicians
- 220 medical students
- Across health care institutions (16)
- Data access more than 628,000 / month





- Information management and Research
  - Technology vs. Information management
  - Examples of costs (time, \$) –Payne 1990
  - Data volume, storage, accuracy, access. – Mohr 1998
- 97年8月17日

***COSTAR and RESEARCH***

“The *clinical question* addressed is whether long-term therapy with NSAIDs interferes with blood pressure control in patients with essential hypertension.”

OUTCOME CRITERIA FOR DATABASE PAIRS -

A. NSAIDs

B. No NSAIDs

1. Increase in diastolic BP,
2. Addition of or the substitution of more potent antihypertensive medications.

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

- **RECORDS ANALYSED >30,000**
  - **PATIENTS SELECTED 90 PAIRS**
  - **11 SELECTION CRITERIA**
  - **TWO OUTCOME CRITERIA**
- Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)
- 97年8月17日

**FINDING MATCHES FOR NSAID-EXPOSED PATIENTS**

FIND AVERAGE DP FOR 12 WEEKS

RECORD NUMBER OF AVAILABLE BP OBSERVATIONS IN INTERVAL IN EXPOSED PTS

STATUS OF ALL MEDICATIONS IN GIVEN CATEGORIES

DETERMINE GIVEN REGIMES HAD NOT CHANGED IN TIME UNDER CONSIDERATION

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97年8月17日

### RESULTS:

1. Manual review of the records to select exposed patients would have required the review of 30,000 patient records to determine if eligibility were met.
2. Conservatively this meant over 180 person-hrs to select patients to meet all eligibility criteria.
3. Manual review for desired criteria 60 person-hrs required

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97MAR17E

### ESTIMATES FOR MANUAL DETECTION OF DISCONTINATION OF MEDICATIONS

2 MIN PER ENCOUNTER FOR MANUAL REVIEW  
6300 PERSON-HRS:  
(90 PTS x 700 ENCOUNTERS/PT x 3 DRUG  
REVIEWS/ENCOUNTER x 2 MIN/DRUG REVIEW)

"This does not include manual record review to determine other match criteria"

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97MAR17E

### NECESSARY COMPONENTS FOR DATABASE STUDY

LARGE DATABASE OF RECORDS  
ENCODED DATABASE  
QUERY LANGUAGE

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97MAR17E

### COSTAR-(Computer-Stored Ambulatory Record)

All patient record information is linked to a **CODE**  
**CODES** are **STORED IN DIRECTORIES**  
**VARIANTS** of the base code are indicated by **MODIFIERS**  
Reference to a **CODE** is called an **EVENT**  
Each event has a **STATUS** for the encounter  
**CODES** -organized by hierarchical **DIVISIONS**-e.g. physical, lab's, therapy, etc.  
**SUMMARY STATUS** gives "current status" of the code.

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97MAR17E

## COSTAR and RESEARCH

### BENEFITS OF A LARGE INTEGRATED CLINICAL DATABASE FOR RESEARCH

1. Little additional expense in data collection
2. All relevant patient experience is potentially available for the study
3. Coding of clinical information permits detailed patient matching that would be difficult to achieve with the paper record
4. **Time savings:** this study required less than 1/2 year of investigator time in selection, matching and determining outcomes.
5. **Standardization** is encouraged yet variability is permitted within the COSTAR EMR.

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

" In clinical epidemiological studies of the impact of therapy..... the most cogent predictors of prognosis are found in clinical, morphologic, and laboratory variables, not purely in demographic data. Yet the demographic information is often the main or only source of variables used for adjustments in these studies." Feinstein 1985.

Payne TH, and others. Conducting a matched pairs historical cohort study with a computer-based ambulatory record system. *Comput.Biomed.Res.*23,455-72(1990)

97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

Quantitative and qualitative aspects of the VPR for 10 million people.

European and North America data estimates  
 Acute + Chronic care - 70 Tera Bytes  
 Acute + Intermediate + Chronic - 175 Tera Bytes needed

**No challenge** for networked computers and could be accommodated in one institution

97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

**“the average half-life of medical data (acute) is less than 3 months.”**

<b>ACUTE:</b>	<b>%USEFUL 6.64%</b>
<b>INTERMEDIATE:</b>	<b>%USEFUL 0.24%</b>
<b>LATE:</b>	<b>%USEFUL 0.01%</b>

*[Much of the initial data capture is of poor quality using existing record systems.]*

97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

**VALUE OF DATA DETERMINES WHETHER TO STORE ACCESS RETRIEVE**

97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

**POTENTIAL SOLUTIONS FOR USING VPR DATA**

**INCREASE ITS VALUE OR PRESERVE ITS VALUE**

**IMPROVE THE ACCESSIBILITY TO THE DATA**

97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

**“the ability to access specific data is more of an issue than storage capacity.”**

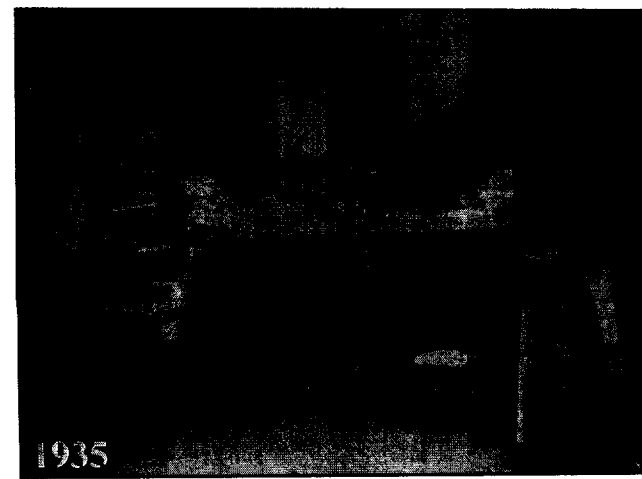
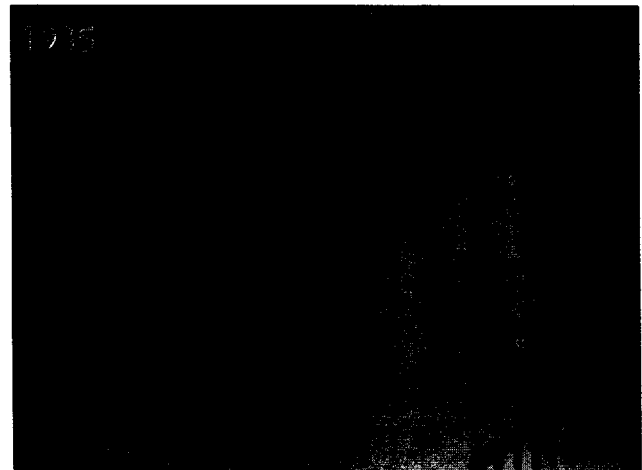
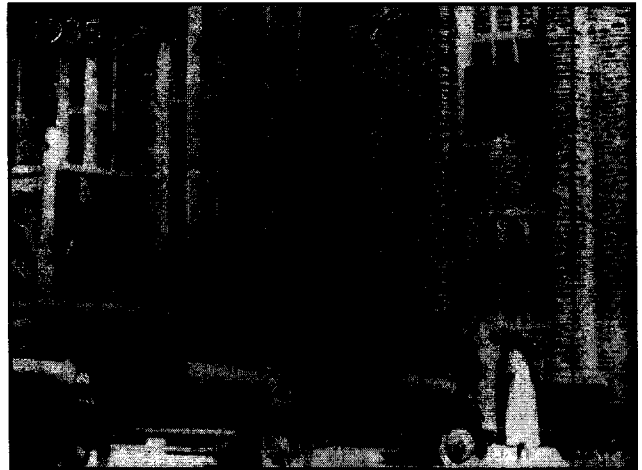
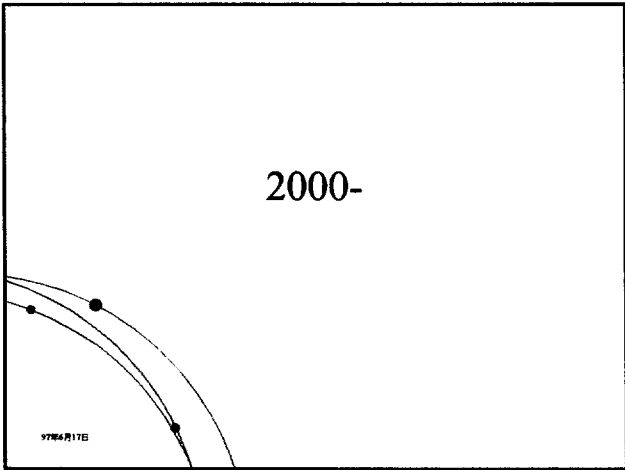
**“It costs us \$5.4 billion a year because tests or second opinions cannot be located.”**  
 National Health Information Infrastructure Act 2003  
 Nancy Johnson US Congress

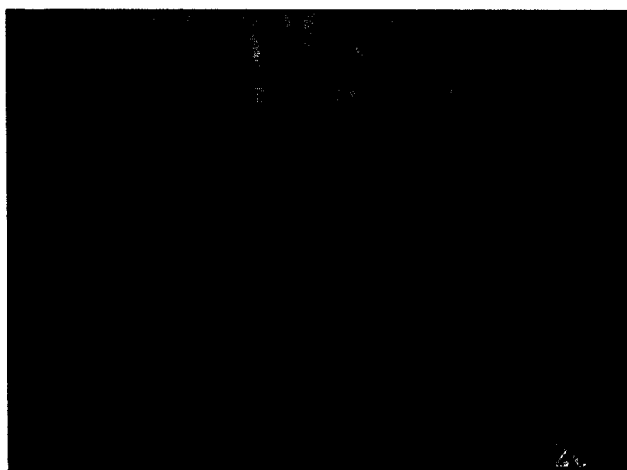
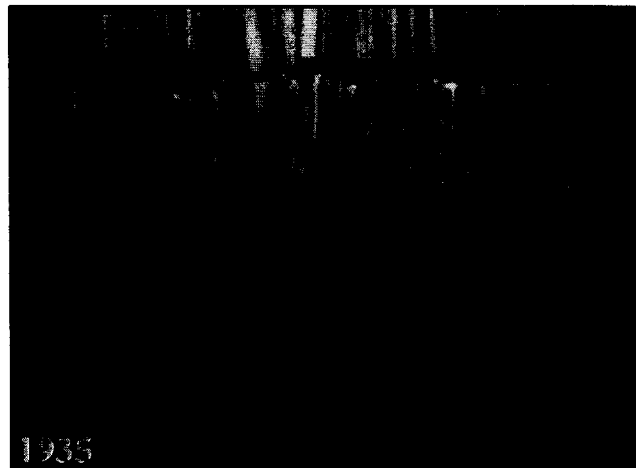
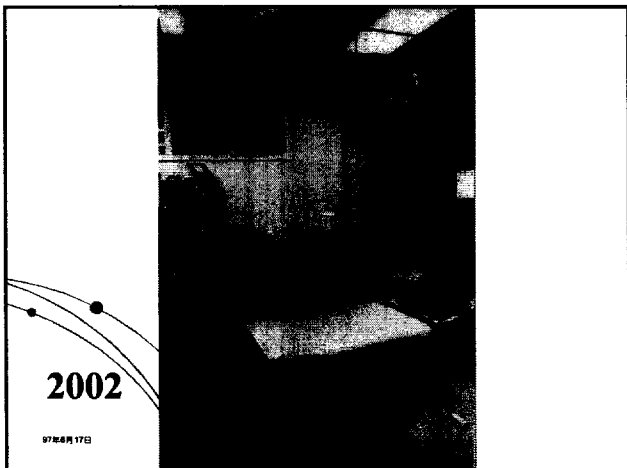
97MAR17E

A quantitative perspective on the Virtual Patient Record (VPR) and its realization.  
 Jochen R. Mohr. Proceedings 9th MEDINFO August 1998. Seoul, Korea

**“Rapid decay is demonstrable from access rates to archival data....and data for research has a low basic quality, ....the lack of completeness...and value is extremely low to begin with...“while the data accumulate gradually to an appreciable but manageable level their value decreases drastically.”**

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### CLINICAL DECISION SUPPORT(CDS)

Provides clinicians, staff, patients or other individuals with:

- with knowledge and person-specific or population information
- intelligently filtered or presented at appropriate times
- to foster better health processes
- better individual patient care
- and better population health.

the concept also applies to computerised and non-computerized knowledge delivery, such as paper mailings and brochures.

Y784 R17B

*Clinical decision support* - One of the most important justifications for CPOE is its potential for improving care. Orders directly reflect the physician's plan for the patient; the best time to influence the physician's plan is at the time the order is being written.

Y784 R17B

- CDS interventions include;
- alerts
  - reminders
  - order sets
  - other techniques for knowledge delivery
    - clinical guidelines
    - patient data reports
    - dashboards
    - documentation templates
    - diagnostic support
    - clinical workflow tools
      - reference information
      - education (delivered with or without context sensitivity)
    - health/clinical protocol and workflow orchestration support
    - display of context-relevant data
    - topic-oriented documentation form
    - others.
- Y784 R17B

CDS **has been effective** in improving outcomes at some health care institutions and practice sites by making needed medical knowledge readily available to knowledge users.

Elsewhere CDS has been **problematic** stalled in the planning stages never even attempted

**Result**, relevant medical knowledge that should be brought to bear is not always available or used.

This is an important contributor to the well documented problems and sub-optimal performance of our health care system.

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In addition:  
Growing consumerism  
Efforts to shift the costs of care to patients  
Expand patient participation in health care decisions

Driving forces for increasing patient and consumer demand for access to reliable medical information.

[Information management is care -Shortliffe and Cimino "Biomedical Informatics"]

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## The Case for CDS

2000 Institute of Medicine report, *To Err Is Human: Building a Safer Health System*, outlined the pervasiveness of medical errors in the (U.S.)health system. It "**has floundered in its ability to provide consistently high quality care to all Americans (and in other nations)**" and noted that the system "**frequently falls short in its ability to translate knowledge into practice.**"

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CDS should ensure that the best clinical knowledge and recommendations are utilized to improve health management decisions.

Then we can achieve:

Desirable levels of patient safety

Care quality

Patient centeredness

Cost-effectiveness requires that the health system optimize its performance through consistent, systematic, and comprehensive application of available health-related knowledge

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## 2001 IOM catalogued studies of the failures to transfer knowledge into practice.

•**Underuse**-Immunization of Adults- Gardner P., Schaffner W. N

Engl J Med. 328;1252-8;1993

**Overuse**- Physician inpatient order writing on microcomputer workstations-effects on resource utilisation. WM Tierney and others. JAMA 1993;269:379-383

•**Misuse of care**-J Antimicrob Chemother. 2008 Apr;61(4):953-8.

A 3 year survey on the use of antibacterial agents in five Italian hospitals. Vaccheri A, and others.

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2-year period covering 1998/99 (PRH0s-UK.)

87% Unnecessary out-of-hours tests (5-50% cases)

80% Diagnostic uncertainty

79% Medico-legal protection

66% Avoid leaving work for colleagues

71% Prevent criticism from staff (especially Consultants)

76% Lessen anxiety and reduce stress levels

71% Agreed attempts should be made to reduce unnecessary testing

McCannell AA, Bowie P. Health Bull (Edinb). 2002 Jan;60(1):40-3.

Unnecessary out-of-hours biochemistry investigations—a subjective view of necessity.

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## Very little change since 2000!

In 2003, the RAND Corporation found that on average patients receive recommended care only 54.9 percent of the time. (Leape, 2005, McGlynn et al., 2003).

Of what we do in routine medical practice, what proportion has a basis in published scientific research?

- |                             |        |
|-----------------------------|--------|
| 1. <i>Williamson (1979)</i> | <20%   |
| 2. <i>OTA (1985)</i>        | 10-20% |
| 3. <i>OMAR (1990)</i>       | <20%   |
| 4. <i>B. James (2007)</i>   | 20-40% |

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One of the causes of this chasm is the gap between the most current and evidence-based clinical and health knowledge, and the information that is typically applied in making health and care decisions.

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**Clinical Knowledge:** A generally applicable fact (or set of facts), best practice, guideline, logical rule, piece of reference information (such as a text article), or other element of information that is important to know for optimal data interpretation and decision-making regarding individual and population health and health care delivery.

In a CDS system, a CDS intervention may use knowledge in at least two ways: as a logical rule to determine whether to deliver information, and as the information to be delivered itself.

**Example of clinical knowledge:** "A mammogram should be ordered for any woman over 40 who has never had one." A characteristic of clinical knowledge is that it can be open to controversy and often evolves over time.

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**Clinical Information Systems:** applications and hardware that manage patient care-related data.

Application examples include Computerized Provider Order Entry (CPOE), Electronic Health Records (EHR), Personal Health Records (PHR), and departmental systems such as those that manage pharmacy, radiology and nursing information.

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Balas and his colleagues found that it may take as long as 17 years to apply 14 percent of research knowledge to patient care (Balas et al., 1998). And as the knowledge base grows, the gap widens.

It is estimated that the medical literature is doubling every 19 years, and in some fast-moving subspecialties, such as AIDS related health care, it may be doubling every 22 months.

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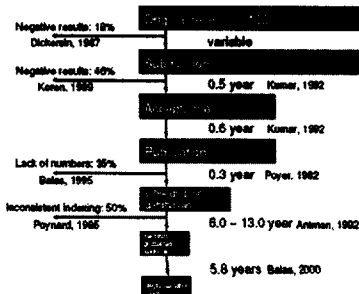




Figure 1.20. Phases in the transfer of research into clinical practice. A synthesis of studies focusing on various phases of this transfer has indicated that it takes an average of 17 years to make innovation part of routine care (Balas and Boron, 2000). Pioneering institutions often apply innovations much sooner, sometimes within a few weeks, but nationwide introduction is usually slow. National utilization rates of specific, well-substantiated procedures also suggests a delay of two decades in reaching the majority of eligible patients. (Courtesy of Dr. Andrew Balas.)

National Institutes of Health

Fact Sheet *Human Genome Project*

<http://www.nih.gov/about/researchresultsforthepublic/HumanGenomeProject.pdf>


9786/17B

# Engaging Patients in e-Health in Three Easy Steps

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**Foreign or Familiar territory?**

Age  
Gender  
Previous computer experience  
-NOT factors in usage  
[W.Stack 1976]





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*Senior Netizens-D. Kadlec, TIME, February 12, 2007*

USA adults > 50 years-54% use Internet (38% 2002)  
25% high speed Internet access (5% 2002)  
Greatest use 50-69 yrs. Rapid fall > 70 years  
Of those > 50 years who use Internet

- 87% use email
- 81% use Google
- Average 9 hrs/week on line

“The idea of being able to discover your own world is very exciting”  
the computer enables us to stay in the work force longer.”

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At BWH, order entry (CPOE) has been the single most effective tool in improving the quality of care via the computer.

100% orders on adult inpatient services are entered through BICS. 85% of these orders are entered by doctors, including residents and senior staff; 10% by nurses in response to voice orders; and 5% by midwives, physician assistants, and students. Orders entered on any patient from any workstation a great convenience to doctors with patients on many care units. This universal access greatly reduces the number of verbal orders, because the primary reason (doctor too far away to write the order) is eliminated.

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**CPOE**  
Assist physicians writing orders by streamlining and structuring the order entry process.

Insure completeness and correctness of medication and other therapeutic orders, as well as diagnostic and procedural orders.

Automated checking within order entry systems for medications can prevent untoward drug interactions.

Allergic reactions.

Perform drug dosing adjustment calculations based upon patient weight, age, renal function, or other physiologic parameters to prevent dangerous or ineffective drug dosing.

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**The Evidence to Date:**

the effect of health information technology on quality, efficiency, and costs of care found that three major benefits on quality were demonstrated—(Chaudhry et al., 2006).

- increased adherence to guideline-based care,
- enhanced surveillance and monitoring,
- decreased medication errors

97864/1718

**1973**

**DECISION MAKING—CLINICAL RESOURCES—COSTS**

Nursing units with annual expenditure \$44 million  
Often on units < \$20 each (more with newer technologies)

2.2 million clinical decisions per year

6,000/day

6 per patient per/d on average

Impact on patient care, costs and data affecting future decisions

*Johns RJ and Blum BF. The use of clinical information systems to control costs as well as improve patient care. Trans Am Clin Climatol Assoc. 1973; 90:140-152*

97864/1718

Examples of BICS interventions include:

1. **Substitute therapy alerts**—suggesting alternatives according to rules determined by senior clinical staff
  - to ordered medications
  - therapies
  - diagnostic studies
2. **Structured ordering**—
  - prompting for reasons for use of studies and therapies when the added information suggests a better alternative
3. **Drug family checking**—
  - drug allergies
  - drug interactions
  - Drug family conflicts
  - Optimal drugs in a class (patient characteristics and by payor)
4. **Consequent orders**—prompting for
  - drug levels e.g. after ordering gentamicin, prophylactic heparin when a patient is placed at bed rest.

97864/1718

5. **Parameter checks: suggestion**—offering default doses and frequencies for every medication order tailored to properties such as age and renal function warning of possible overdoses.

6. **Redundant utilization checking**—

- warning when a slowly-varying lab test is ordered repeatedly within a short interval.

7. **Relevant information display**—

- displaying relevant recent lab results when medications are being ordered
- cross-match status for blood product ordering
- charges for diagnostic tests.

97864/1718

8. **Time-based checks**—

posting reminders for time-sensitive orders e.g. clinical pathway, protocol, or parenteral-nutrition orders for the day.

9. **Order sets and templates**—

standard collections of orders (with relevant information and optional orders). (35% of all orders).

Providers may create their own order sets, but they are invisible to others.

Departmentally-approved sets and templates are available to all.

10. **Patient profile display: analysis**—

periodic analysis and display of a patient's overall clinical status, and communication of information to other providers as needed.

11. **Rule-based event detection**—using the BICS Event Engine

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Other CDS manoeuvres during CPOE:

Showing the cumulative charge display for all tests ordered

Reminding about redundant tests ordered

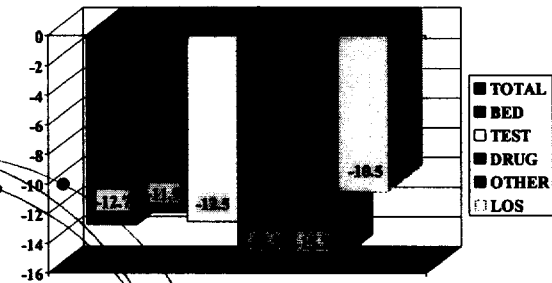
Providing counter-detailing during order entry

Reminding about consequent or corollary orders may also impact resource utilization.

*(Johns & Blum 1973; Overhage et al., 1997; Bates et al., 1999; Bates and Gawande, 2003; Bates, 2004; McDonald et al., 2004).*

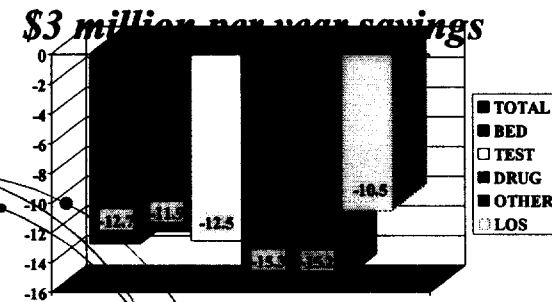
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**USING PHYSICIAN INPATIENT ORDER WRITING ON MICROCOMPUTER WORKSTATIONS. REDUCTION IN HEALTH CARE RESOURCE UTILISATION**



Physician inpatient order writing on microcomputer workstations-effects on resource utilisation. WM Tierney and others. JAMA 1993;269:379-383

**USING PHYSICIAN INPATIENT ORDER WRITING ON MICROCOMPUTER WORKSTATIONS. REDUCTION IN HEALTH CARE RESOURCE UTILISATION**



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**Deep Post-Operative Wound Infections at LDS Hospital, Utah Intermountain Health Care, Salt Lake City, Utah, USA**

	1985	1986	1991
% Prophylaxis given at optimal time	40%	58%	96%
% Infections	1.8%	0.9%	0.4%
Estimated decrease in infections relative to 1985	-	33%	51%
Estimated savings at \$14,000 / case (in thousands \$)	-	\$462 K	\$714 K

National standard 2 - 4% infection rate

Larsen RA, et al, *Infect Cont & Hosp Epi* 1989;10:316-320  
 Classen DC, et al, *New Engl J Med* 1992; 326:281-6

07/24/91

**Intermountain Health Care, Salt Lake City, Utah, USA**

Overall antibiotic use:	decreased 22.8%
Mortality rates:	decreased from 3.65% to 2.65%
Antibiotic-associated ADE:	decreased 30%
Antibiotic resistance:	remained STABLE
Appropriately timed preoperative a/biotics:	40% to 99.1%
Antibiotic costs per treated patient:	decreased \$122.66 to \$51.90
Acquisition costs for antibiotics:	fell 24.8% to 12.9% (\$987,547) to (\$612,500)

Our case-mix index which measures patient acuity levels INCREASED during this period, meaning we were treating sicker and sicker patients while better utilizing the delivery of antibiotics.

Pestotnik, S. L., Classen, D. C., Evans, R. S., Burke, J. P. Implementing antibiotic practice guidelines through computer-assisted decision support: clinical and financial outcomes *Ann Intern Med* 1996 May 15

07/24/91

R.M. Gardner et al. International Journal of Medical Informatics 54 (1998) 164-172 177

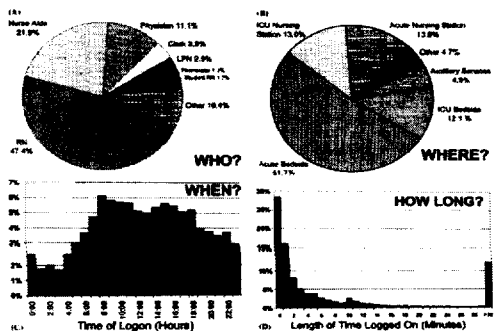
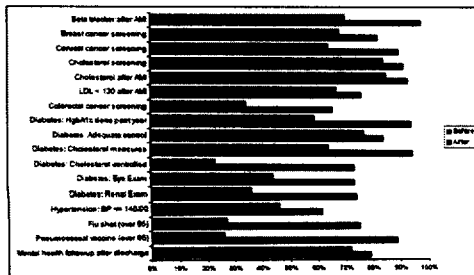


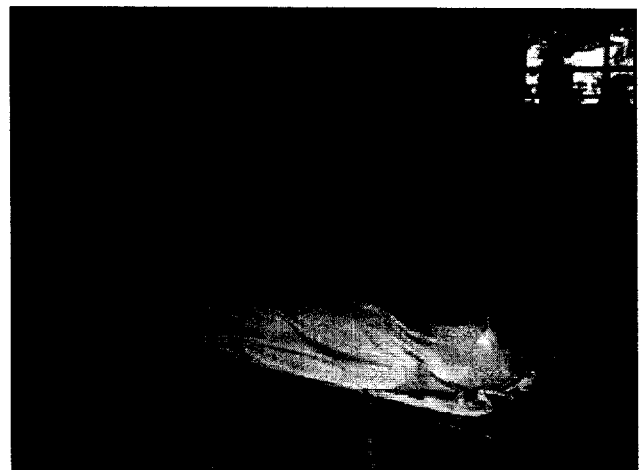
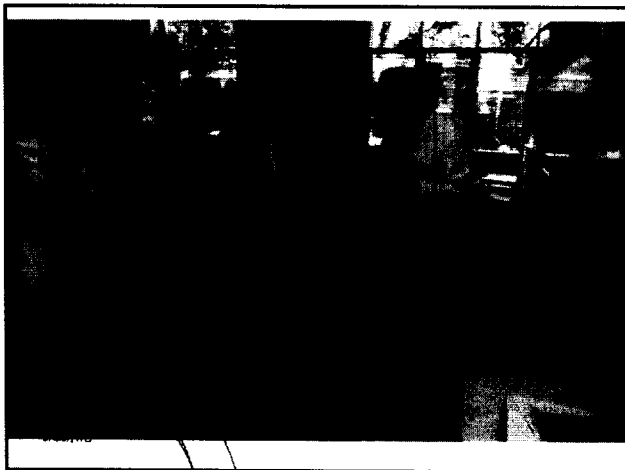
Fig. 2. Charts outlining how the HELP system is used and by whom. (A) WHO? Indicates who the HELP system users are. Almost half the HELP system logons are by nurses. (B) WHERE? Shows where the HELP terminals are used. A major use of the system is from the bedside area where the terminals are used for running data entry and review. (C) WHEN? Indicates when (time of day) the HELP system is used. (D) HOW LONG? Indicates how long the user is active at a HELP system terminal. Note that the majority of the time interactions are for less than 5 min.

**VA's Success with Decision Support**



Data Source: Thomas TC, Broder DJ. The Benefits of Health Information Technology: Delivering Consumer-centric and Information-rich Health Services. Washington, DC: US Department of Health and Human Services; 2004.





**MEASURING & MANAGING HEALTH CARE**

The foundation for quality patient care is information –  
**Comprehensive**  
**Accurate**  
**Up-to-the-minute clinical information**

You manage what you measure- *Brent James IHC, QMMP project.*  
*Chicago, Illinois. 1989*

To improve care, you have to measure it. W.Tierney, Regenstrief  
Institute, Indiana.

07MAR17E

**AIDS in Africa**

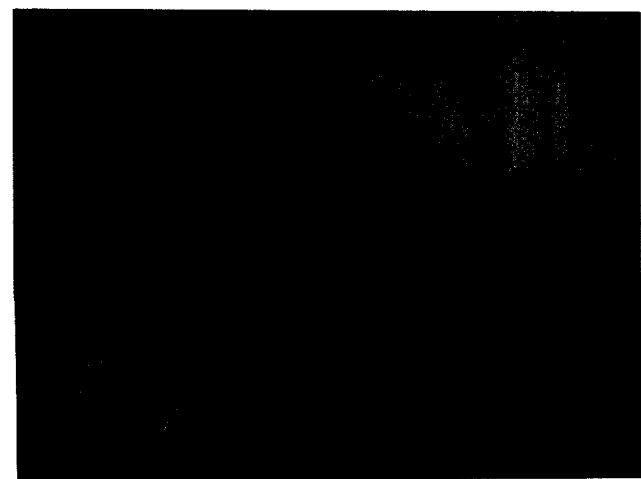
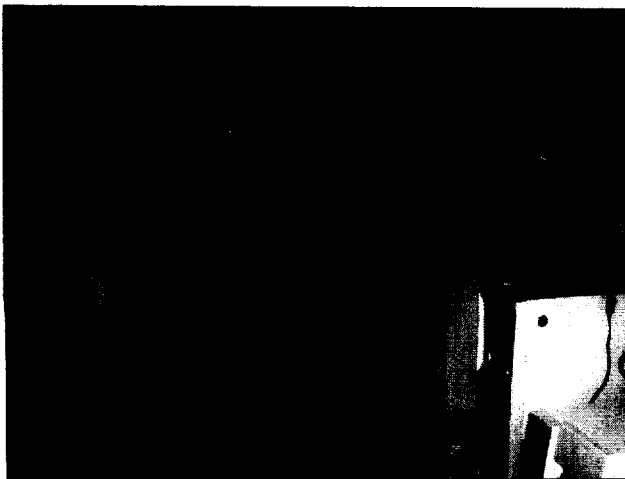
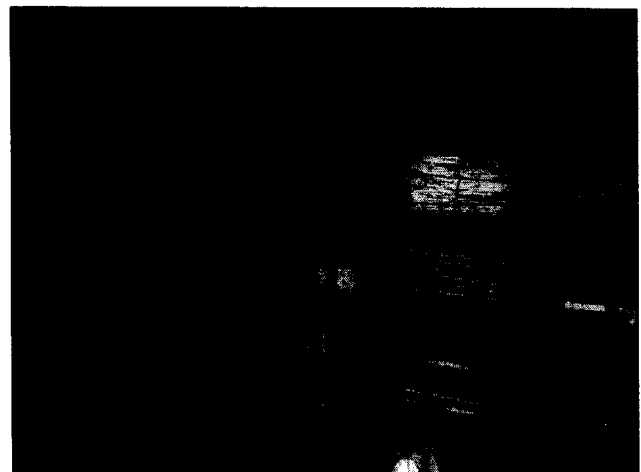
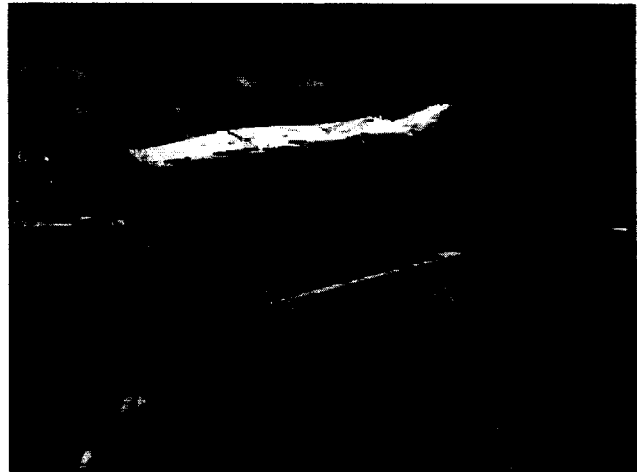
- HIV/AIDS is the worse disaster in history
  - >42 million persons infected worldwide
  - >25 million (70%) are in sub-Saharan Africa
- In Kenya...
  - 2.5 million persons infected (15% of adults)
  - 4<sup>th</sup> behind South Africa, India, and Nigeria
  - 1 million AIDS orphans (of 31 million citizens)
  - life expectancy has dropped 18 years in the past 5 years, from 65 → 47 years

07MAR17E

## Indiana and Moi Universities

- 14-year collaboration
- 1<sup>st</sup> 11 years → focus = educational exchange
- In 2001 Joe Mamlin returned
  - found >50% of the beds in Moi Hospital were filled with young people dying of AIDS
  - no ARVs, few antibiotics for opportunistic infections

070608 170



MMRS data (2 years)  
>66,000 pt visits

Diagnoses	# Visits	Drugs	# Visits
Malaria	17,495	Paracetamol	24,944
URI	8,479	Fansidar	11,550
Septic wound	1,329	Quinine, injected	8,769
Gastroenteritis	964	Penicillin, injected	8,058
Tonsillitis	938	Quinine, oral	7,851
Wound (unspec.)	791	Penicillin, oral	4,753
Myalgia	700	Amoxicillin	4,725
Amebiasis	629	Depoprovera	4,443
Laceration	618	Piriton	3,766
Worms (unspec.)	544	Brufen	3,323

MMRS data (2 years)

	Charges	Amount Paid
Drug Charges	4,260,398	692,691 (17%)
Test Charges	1,011,727	424,630 (42%)
<b>Total Charges</b>	<b>5,272,605</b>	<b>1,117,580 (21%)</b>

Effects on patients and clinicians

- Patient time (minutes per visit)
  - waiting: 21 → 13 minutes
  - with provider: 12 → 5 minutes
  - registering: 1.8 → 2.5 minutes
  - total time per visit: 42 → 32 minutes

Effects on patients and clinicians

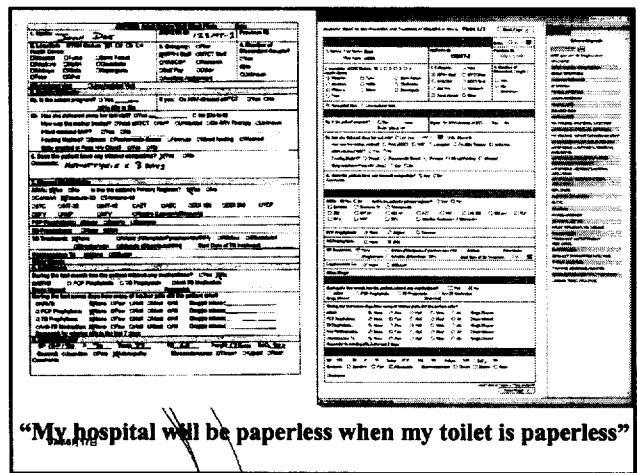
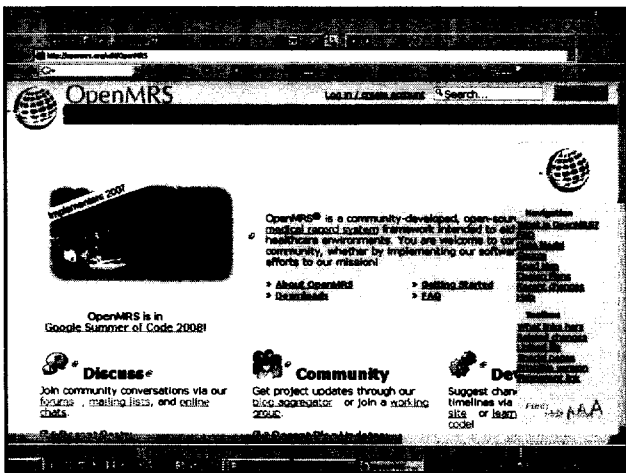
- Patient time (minutes per visit)
  - waiting: 21 → 13 minutes
  - with provider: 12 → 5 minutes
  - registering: 1.8 → 2.5 minutes
  - total time per visit: 42 → 32 minutes
- Clinician time (% of workday)
  - with patients: 33% → 16%
  - with other staff: 23% → 8%
  - personal activities: 15% → 46%
  - searching for information: 7% → 3%

Administrative uses of MMRS data

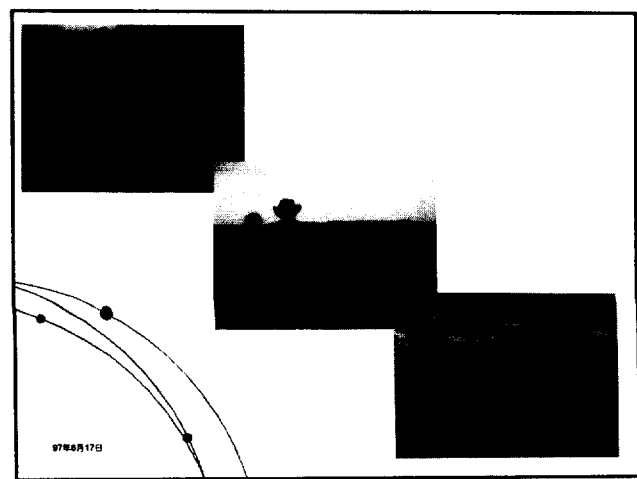
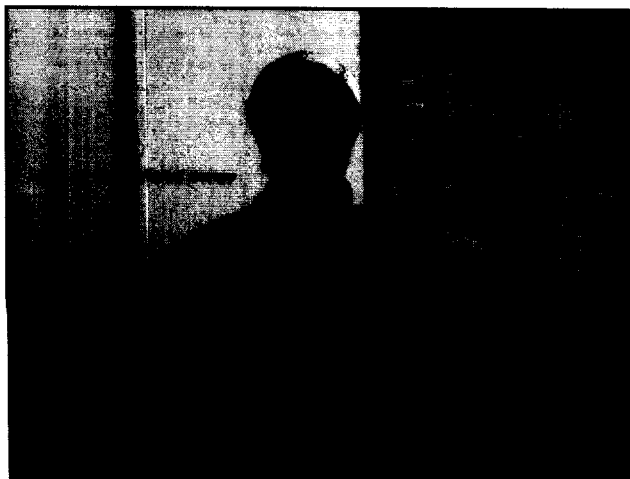
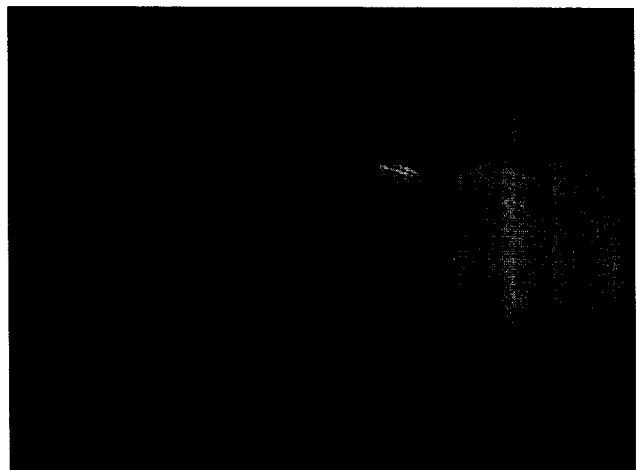
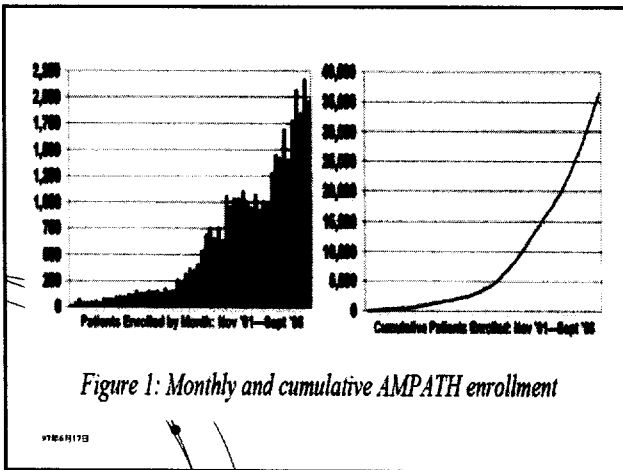
- From 2 weeks → 1 hour to produce monthly MOH reports (#1 among rural health centers)
- Document drug use → order refills earlier
- Quantify amount of free care provided → increased funding from the Kenyan MOH
- MOH advisory committee recommended that the MMRS be used in all rural health centers

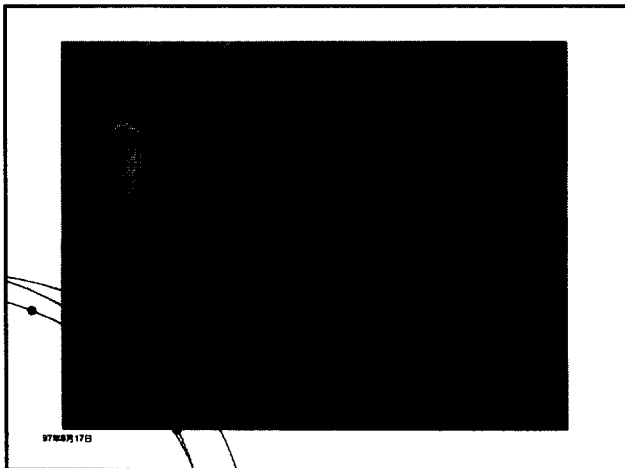
Clinical uses of MMRS data

- Noted a village with too few children being vaccinated → nurse sent to intervene: vaccinate, educate
- Noted a village with too many STIs → nurse sent to intervene: identified the culprit, treated contacts, educated residents
- Noted many dog bites in one area → rabid dog found biting dogs, humans → destroyed



"My hospital will be paperless when my toilet is paperless"





**Computer Provider (nee Physician) Order Entry Definition**

**Definition:**  
 CPOE is not a technology, rather it is a design (or redesign) of clinical processes that integrates technology to optimize provider ordering of medications, laboratory tests, procedures, etc.

Its core is an interactive decision support system.

Unlike other clinical decision support systems, CPOE is distinguished by the requirement that the provider is the primary user.

We note several specific factors that have helped support the development, acceptance, and impact of BICS. Any healthcare institution that wants to use advanced clinical systems (whether home-built or vendor-supplied) must have most of these in place for success:

1. Senior management backing.
2. Quality focus.
3. Clinician input.
4. Past successes.
5. Champion identification.
6. Post-implementation support.
7. Quality review process.

**CDS has impacted on:**

**Utilization of expensive medications, and radiologic tests and procedures.**  
 Order entry in a CPOE system can help eliminate overuse, underuse, and misuse (Teich et al., 2000; Bates et al., 2003; Austin et al., 1994; Linder, Bates and Lee, 2005; Tierney et al., 2003).

**Medication ordering/prescribing:**  
 Suggesting brand to generic substitutions for more cost-effective therapies, or more formulary compliant drug options (Teich et al., 1999; Fischer et al., 2003; Wang et al., 2003).

**Expensive radiologic tests and procedures:**  
 At point of ordering can guide physicians toward the most appropriate and cost effective, radiologic tests (Harpole et al., 1997; Bates et al., 2003; Khorasani et al., 2003).

**Physicians and IT in health**

- While electronic health records represent a major tool to help achieve quality and productivity improvement, only 17% [1] of US physicians are using them on a regular basis.
- The benefits of these technologies include:
  - (1) instant access to patient health data,
  - (2) clinical decision support at the point of care,
  - (3) transmission and receipt of lab requests and results,
  - (4) information aimed at avoiding medication errors, and
  - (5) physician-performance measurement.

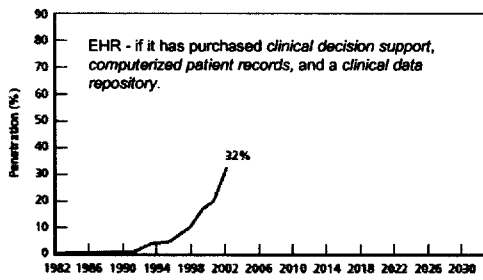
Burt C. Hing E. Use of computerized clinical support systems in medical settings: United States, 2001-03. CDC Division of Health Statistics. March 15, 2005. Available at: <http://www.cdc.gov/nchs/data/ad/ad353.pdf> Accessed June 20, 2005.

**The Evidence to Date:**

the effect of health information technology on quality, efficiency, and costs of care found that three major benefits on quality were demonstrated –(Chaudhry et al., 2006).

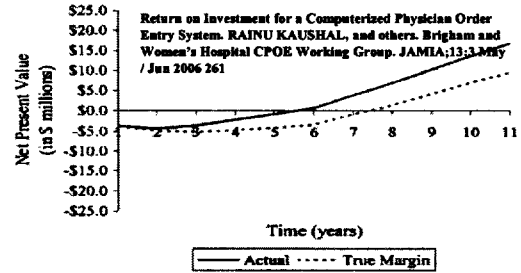
- increased adherence to guideline-based care,
- enhanced surveillance and monitoring,
- decreased medication errors

**Figure 2.2**  
Diffusion of Electronic Health Records in Acute-Care Hospitals



SOURCE: Dornfest 2002 data and RAND analysis.  
NOTE: n = 3,979.  
RAND MR21.2

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**Figure 1.** The net cumulative present value of computerized physician order entry (CPOE) at Brigham and Women's Hospital (BWH) from 1992 to 2002 given an 80% prospective reimbursement rate. Six years after the implementation of CPOE, in 1998, BWH began to make a net profit from the CPOE system. This net profit continues to grow steeply. In 1999, 7.5 years after the implementation of CPOE, a financial benefit accrued in the operating budget.

**Table 2 ■ Annual Benefits for CDSS Elements at Brigham and Women's Hospital**

CDSS Element	Total Benefits
Renal dosing guidance	2.24
ADE prevention	1.05
Nurse time utilization	0.96
Specific or expensive drug guidance (human growth hormones, vancomycin, ceftriaxone, ondansetron, histamine-2 receptor blockers)	0.88
ADE monitor	0.76
Intravenous to oral guidance	0.74
Laboratory charge display and redundant laboratory warnings	0.34
Panic laboratory alerting	0.34
Radiology indications, rule-out, and assistant	0.15
Automated medication summary at hospital discharge	0.10
Physician time utilization	0.10
Elderly dosing guidance	0.05
Specific drug level guidance (antiepileptics, rheumatologic tests)	0.02

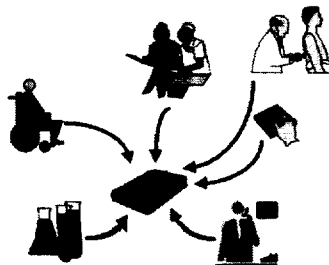
This table depicts the annual benefits (in 2002 millions of dollars) for each element of CDSS at Brigham and Women's Hospital given an 80% prospective reimbursement rate.

**Definition:**

In summary, we define *biomedical informatics* as the scientific field that deals with biomedical information, data, and knowledge—their storage, retrieval, and optimal use for problem solving and decision making.

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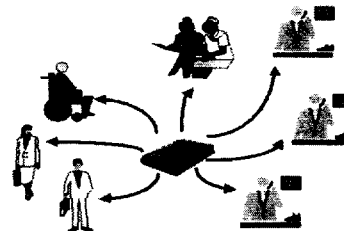
6 E. H. Shortliffe and M. S. Bois



**Figure 1.1.** Inputs to the medical record. The traditional paper medical record is created by a variety of organizational processes that capture varying types of information (notes regarding direct encounters between health professionals and patients, laboratory or radiologic results, reports of telephone calls or prescriptions, and data obtained directly from patients). The record thus becomes a merged collection of such data, generally organized in chronological order.

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Emergence of a Discipline 7



**Figure 1.2.** Outputs from the medical record. Once information is collected in the traditional paper medical record, it may be provided to a wide variety of potential users of the chart. These users include health professionals and the patients themselves but also a wide variety of "secondary users" (represented here by the individuals in business suits) who have valid reasons for accessing the record but who are not involved with direct patient care. Numerous providers are typically involved in a patient's case, so the chart also serves as a means for communicating among them. The mechanisms for displaying, analyzing, and sharing information from such records result from a set of processes that often vary substantially across several patient care settings and institutions.

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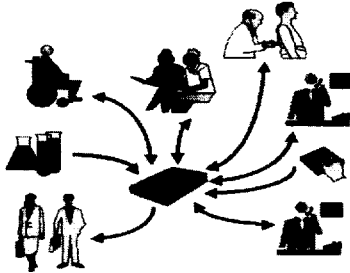


Figure 1.3. Complex processes demanded of the record. As shown in Figures 1.1 and 1.2, the medical record is the instrument of a complex set of organizational processes, which both gather information to be shared and then distribute that information to those who have valid reasons for wanting it. Paper-based documents are severely limited in meeting the diverse requirements for data collection and information access that are implied by this diagram.

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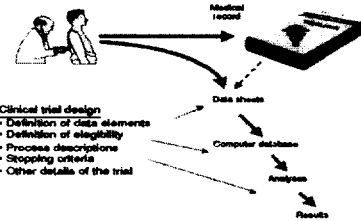


Figure 1.4. Conventional data collection for clinical trials. Although modern clinical trials routinely use computer systems for data storage and analysis, the gathering of research data is often a manual task. Physicians who care for patients enrolled in trials are often asked to fill out special worksheets for later transcription into computer databases. Alternatively, data managers are hired to abstract the relevant data from the traditional paper chart. The trials are generally designed to define data elements that are required and the methods for analysis, but it is common for the process of collecting these data in a structured format to be left to manual processes at the point of patient care.

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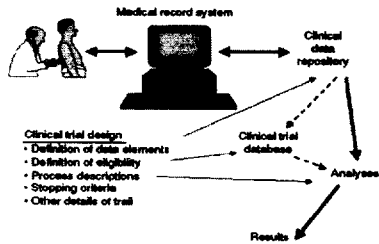


Figure 1.5. Role of electronic health records (EHRs) in supporting clinical trials. With the introduction of computer-based patient record (CPR) systems, the collection of research data for clinical trials can become a by-product of the routine care of the patients. Research data may be analyzed directly from the clinical data repository, or a secondary research database may be created by downloading information from the online patient records. The manual processes in Figure 1.4 are thereby eliminated. In addition, the interaction of the physician with the medical record permits two-way communication, which can greatly improve the quality and efficiency of the clinical trial. Physicians can be reminded when their patients are eligible for an experimental protocol, and the computer system can also remind the clinician of the rules that are defined by the research protocol, thereby increasing compliance with the experimental plan.

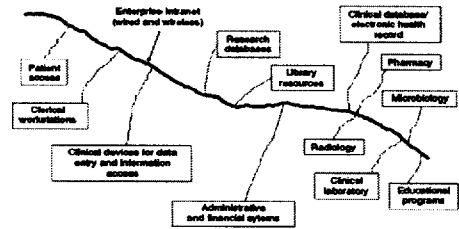


Figure 1.6. Networking the organization. We already live in an era when large hospitals and health care systems have implemented widespread networking technologies that allow diverse systems and users to communicate with one another within their organization. The enterprise server is a locally controlled network that extends throughout a health care system. It allows specialized workstations to access a wide variety of information sources: educational, clinical, financial, and administrative. An electronic health record (EHR) emerges from such an architecture if a system is implemented that gathers patient-specific data from multiple sources and merges them for ease of access by users such as those illustrated in Figure 1.2. Such systems are often called clinical data repositories, particularly if they do not yet contain the full range of information that would normally occur in a medical record. The enterprise intranet faces challenges of connectivity and integration that are a microcosm of what the larger community experiences in trying to link EHRs and other clinical systems from different organizations.

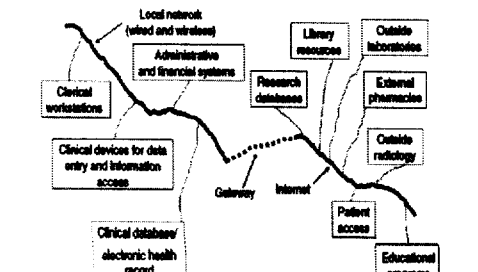


Figure 1.8. Communications networks are increasingly found in outpatient practice settings, including small office practices, but much of their value is enhanced when they are linked through gateways to the Internet and to information resources, organizations, and individuals beyond their own doors.

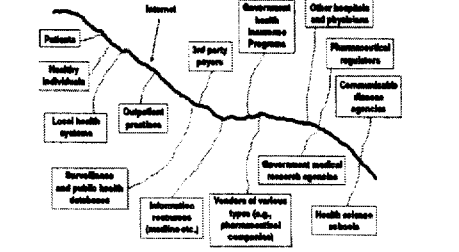


Figure 1.9. Moving beyond the organization. The integrated interconnectivity of all the clinical systems, building on networking technology and standards for data exchange and privacy protection, creates a National Health Information Infrastructure (NHII), which supports clinical care, research, and the public health. The enterprise Intranet is the integration of an organization's intranet (Figure 1.6, encapsulated in the box here labeled "Local Health System") with the full potential of the worldwide Internet. Both providers and patients increasingly access the Internet for a wide variety of information sources and functions suggested by this diagram (see text).

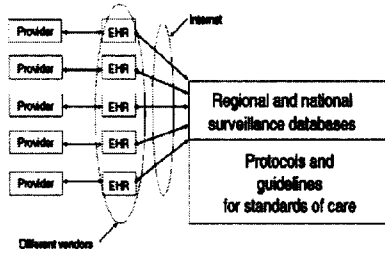


Figure 1.7. A future vision of surveillance databases, in which clinical data are pooled in regional and national repositories through a process of data submission that occurs over the Internet (with attention to privacy and security concerns as discussed in the text). When information is effectively gathered, pooled, and analyzed, there are significant opportunities for feeding back the results of derived insights to practitioners at the point of care.

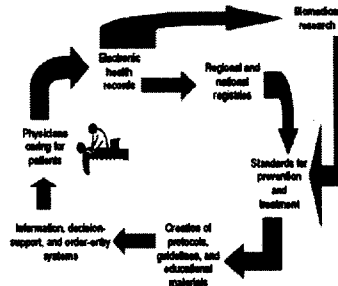


Figure 1.8. The ultimate goal is to create a cycle of information flow, whereby data from distributed electronic health records (EHRs) are automatically submitted to registries and research databases. The resulting new knowledge then can feed back to practitioners at the point of care, using a variety of computer-supported decision support delivery mechanisms.

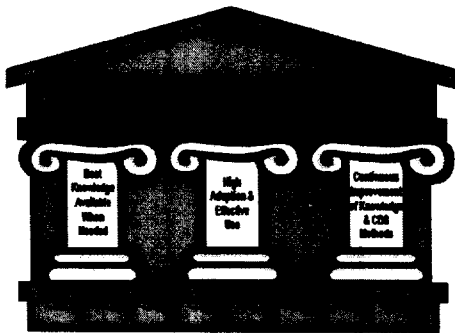


Figure ES-1. The Three Pillars for Realizing the Promise of CDS

9/14/01/17E