Ethics&Health Informatics: Users, Standards, and Outcomes Ethical Issues in Health Informatics The surgeon Sir William Arbuthnot Lane, writing in the November 1936 issue of *New Health:* *More&more tendency is towards use of mechanical aids to diagnosis; *Nevertheless, five senses of doctor do still,&must always, play preponderating part in examination of sick patient. *Careful observation can never be replaced by the tests of laboratory. *The good physician now or in future will never be a diagnostic robot.* *Human values should govern research and practice in health professions *Appropriate& inappropriate behavior **Honorable& disreputable actions **Right&wrong *People often assume that confidentiality of electronically stored patient info is the primary source of ethical attention in informa ics. *Although confidential ity&privacy are indeed of vital importance&significant concern, field is rich with other ethical issues, including appropriate selection&use of informatics tools in clinical settings; *determination of who should use such tools; *role of sys evaluation; *The obligations of sys developers, maintainers,&vendors; *use of computers to track clinical outcomes to guide future practice. *Informatics may engender many important legal&regulatory questions.

Appropriate Use&Users *Clinicians generally evaluate appropriate evidence, standards, presuppositions,& values*To answer clinical question "What should be done in this case?" *What is problem? *What am I competent to do? *What will produce most desirable results? *What will maintain or improve patient care?*How strong are my beliefs in accuracy of my answers to questions 1 to 4?

Appropriate Use *Excitement often accompanies initial use of computerbased tools in clinical settings. *Evidence&reason determine appropriate level of caution. *Example **Electronic laboratory info syss improve access to clinical data **Such syss improve care at an acceptable cost in time and money, *There is less evidence that existing clinical expert syss can improve patient care in typical practice settings at an acceptable cost in time&money. *Humans are still superior to electronic syss at understanding, at collection, interpretation and representation of data,&at clinical synthesis.*The skills required for diagnosis are in many respects different from those required for the acquisition, storage &retrieval of laboratory data. *There is no contradiction in urging extensive use of electronic laboratory info syss, but cautious or limited use (for time being) of expert diagnostic decision support tools. *How&when should computers be used in clinical practice? *Error avoidance&ethically optimized action.

Appropriate Users *Efficient&effective use of health-care informatics syss requires training, experience,&education. *When stakes are high&the domain large&complex (as is true in health professions) education&training take on moral significance. *Who should use a health-care–related computer application? *Example: expert decision-support syss *Potential users of such syss include physicians, nurses, physicians' assistants, paramedical personnel students of the personnel, health sciences, patients,&insurance and government evaluators *To use a diagnostic decision-support sys, the clinician must be able to recognize **When computer program has erred **When it is accurate **What output means **How it should be interpreted *This ability requires knowledge both of the diagnostic sciences&of sw applications&their limitations.

Ethical Principles for Appropriate Use of Decision Support Syss *A computer program should be used in clinical practice only after appropriate evaluation of its efficacy&documentation that it performs its intended task at an acceptable cost in time and money. *Users of most clinical syss should be health professionals who are qualified to address the question at hand on basis of their licensure, clinical training,&experience. *A Sw syss should be used to augment or supplement, rather than to replace or supplant, such individuals' decision making. *All uses of informatics tools, especially in patient care, should be preceded by adequate training& instruction, which should include review of all available forms of previous product evaluations.

Obligations for Sys Developers&Maintainers *Users of clinical programs depend on the developers&maintainers of a sys, and must trust evaluators who have validated a sys for clinical use. *Health-care sw applications are among the most complex technological tools *Complexity commits a sys's developers, designers,&maintainers to adhere to reasonable standards and, indeed, to acknowledge their moral responsibility 4 doing so.

Ethics&Standards *Standard of care embodies a number of complex assumptions linking ethics, evidence, outcomes,&professional training. *Holding patient care as leading value. *Health care syss are not only devices for accounting, entertainment, real estate, etc. *The domain is shaped by pain, illness, and death. *It is essential that threads of trust run throughout fabric of clinical sys design&maintenance. *Quality standards should stimulate scientific pr gress&innovation while safeguarding against sys error&abuse. Users&society have extensive responsibilities to ensure that tools are used appropriately.

Ethical Optimization of a Program 1. Does sys work as designed? 2. Is it used as anticipated? 3. Does it produce desired results? 4. Does it work better than procedures it replaced? 5. Is it cost effective? 6. How well have individuals been trained to use it? 7. What are anticipated long-term effects on how depar ments interact? 8. What are long-term effects on delivery of medical care?9. Will sys have an impact on control in organization?

Privacy, Confidentiality, and Data Sharing *Placing computer applications in healthcare settings while upholding traditional principles. *Balancing two competing values: **Free *access* to info **Protection of patients' privacy and confidentiality. *Other peoplemight use info to harmpatients physcally, emotionally, or financially.*Either improvingcarthrough use of computer-syss, or protectingconfidetiality byrestricting use of computer syss.

Health Privacy&Confidentiality **Privacy* generally applies to people including their desire not to suffer eavesdrop ping *Confidentiality* is best applied to info. *Ex: *If someone follows you&spies on you entering AIDS clinic, your privacy is violated; *If someone sneaks into clinic&looks at your health-care records, your records' confidentiality is violated. *term *privacy* may also refer to individuals' desire to restrict disclosure of personal data *Protecting privacy&confidentiality benefits both individuals&society. *Patients who know that their health-care data wont be shared inappropriately are more comfortable disclosing those data to clinicians. *trust is vital for successful Physician– or nurse patient relationship, &it helps practitioners to do their jobs.

Public Health Benefits of Privacy& confidentiality protections *People who fear disclosure of personal info are less likely to seek out professional assistance, increasing risks that their problem will remain untreated. *Financial harm may occur if insurers are given unlimited access to family members' records, or access to patients' genetic-testing results patients genetic results, because some insurers might be tempted to increase price of insurance 4 individuals at higher risk of illness.

Health Privacy & Confidentiality *Protection of privacy& confidentiality is not an option, a favor, or a helping hand offered to patients with embarrassing health-care problems; *It is a duty that does not vary with the malady, or data-storage medium.

Ways to Restrict Inappropriate Access to Electronic Records *Technological methods:* Computers can provide the means for maximizing their own security, including authenti-cating users, by making sure that users are who they say they are; prohibiting people without a professional need from accessing health info; *Policy approaches: Hospi-tals&other health-care organizations create security&confidentiality commi tees&establish education&training programs. *These recommendations parallel an approach that has worked well elsewhere in hospitals for matters ranging from infection control to bioethics.

Electronic Data and Human Subject Research *The use of patient info for clinical research&for quality assessment raises interesting ethical challenges. *In an optimal environment, then, patients can monitor who is looking at their records *A valuable benefit of electronic health-care record is ability to access vast numbers of patient records to *determine incidence& prevalence of various maladies *track efficacy of clinical interventions *plan efficient resource allocation *Establish safeguards that optimize the research ethically. *Establish mechanisms to anonymize the info in individual records, or to decouple data contained in records from any unique patient identifiers. *This task is not always straight forward

Challenges in Bioinformatics *Safeguards are increas-ingly likely to be challenged as genetic info makes its way into health-care record *The risks of bias, discrimination, and social stigma crease dramatically as genetic data become available to Clin cians& investiga-tors. *In addition, genetic data are rarely associated with only a single person; they may provide info about relatives, including relatives who do not want to know about their genetic makeup or maladies *There is still much work to be done in sorting out and addressing ethical issues related to electronic storage, shar-ing,&retrieval of genetic data

Social Challenges and Ethical Obligations *The expansion of evidence-based medicine *Increasing unwillingness of governments and insurers to pay for interventions and therapies that do not work, or that do not work well enough to justify their cost cost. *Health informatics helps clinicians, administrators, third-party payers, governments, researchers, and other parties to collect, store, retrieve, analyze, and scrutinize vast amounts of data. *Such tasks may be undertaken not for sake of any individual patient, but rather for cost analysis and review, quality assessment, scientific research, and so forth. *These functions are important,&if computers can improve their quality or accuracy, then so much the better. *Challenges arise *when intelligent machines are mistaken for decision making surrogates, or **when institutional or public policy recommends or demands that computer output stand proxy for human cognition.

Effects of Informatics on Traditional Relatio ships *Patients are often sick, scared,&vulnerable. *Medical decisions are shaped by nonscientific considerations *Many clinical decisions are not exclusively medical they have social, personal, ethical, psycholog cal financial familial legal and other components; even art might play a role

Consumer Health Informatics *The growth of World Wide Web&evolution of clin cal&health resources on Internet Ethical importance over next decade **Peer review:* How&by whom is quality of a web site to be evaluated? Who is responsible for the accuracy of info communi-cated to patients? **Online consultations:* There is yet no standard of care for online medical consultations. What risks do physicians and nurses run by giving advice to patients whom they have not met or examined? **Support groups:* Internet support groups can provide succor&advice to sick people

Legal Issues in Health-Care Informatics *Liability under tort law *Potential use of computer applications as expert witnesses in courtroom *Legislation governing privacy and confidential-ity&copyrights, patents, and intellectual property issues.

Liability Under Tort Law *There are few, if any, U.S. legal precedents directly involving harm or injury to patients resulting from use of clinical sw applications *A key legal distinction is difference between products&services. **Products are physical objects, such as stethoscopes, that go through processes of design, manufacture, distribution sale&subsequent use by purchasers distrib tion,sale, purchasers. **Services are intangible activities provided to consumers at a price by (presumably) qualified individuals. *Patients who are harmed by clinical practices based on imperfect sw applications may sue health-care providers for negligence or malpractice *Similarly, a patient might sue a practitioner who has *not* used a decision-support sys, when it can be shown that use of decision-support decision sys is part of current *standard of care*, and that use of program might have prevented clinical error that occurred. *It is not clear whether patients in such circumstances can also sue sw manufacturers, as it is responsibility of the licensed practitioner,&not of the sw vendor, to uphold standard of care in community through exercising sound clinical judgment.

Privacy&Confidentiality * Copyright, Patents, and Intellectual Property** *These issues must be also legally addressed

Summary&Conclusions 1. Specially trained humans remain, so far, best able to provide health care for other humans. Hence, computer sw should not be allowed to overrule a human decision. 2. Practitioners who use informatics tools should be clinically qualified&adequately trained in using thesw products. 3. tools themselves should be carefully evaluated and validated. 4. Health informatics tools&applications should be evaluated not only in terms of performance, including efficacy, but also in terms of their influences on institutions, institutional cultures,&workplace social forces. 5. Ethical obligations should extend to sys developers, maintainers,&supervisors as well as to clinician-users. 6. Education pr grams&security measures should be considered essential for protecting confidential-ity&privacy while improving appropriate access to personal patient info. 7. Adequate oversight should be maintained to optimize ethical use of electronic patient info for scien-tific&institutional research.

Important Factors degree to which a particular CPR demonstrates theseBenefits depends onSeveralFactors: *Comprehensiveness of info*Duration ofUse retention of data*Degree OFStructureOFData *Ubiquity of access.

Computer-Based*What Is a Computer-Based Patient-Record?** *We focus attention on **patient record**, commonly referred to as patient's **chart** or **medical record**. *patient record is an amalgam of all data acquired created during a patient's course through health care sys. *We examine definition use of computer based patient record syss *We discuss their potential benefits costs,& describe remaining challenges to address in their dissemination.

Purposes of a Patient Record Reiser, 1991: * purpose of a patient record is "to recall observations, to inform others, to instruct students, to gain knowledge, to monitor perform-ance, to justify interventions" * logistical, organizational, other practical limitations reduce effectiveness of traditional records 4 storing organizing an ever increasing number of diverse data.

Patient-Record (CPR) ***CPR** is a repository of electronically maintained info about an indivi ual's lifetime health status health care, stored such that it can serve multiple legitimate users of record. *Traditionally, patient record was a record of care provided when a patient is ill. *Managed care encourages healthcare providers to focus on continuum of health health care from wellness to illness recovery.

Computer-Based Patient-Record (CPR) * record must integrate elements regarding a patient's health illness acquired by multiple providers across diverse settings. * data should be stored such that different views of those data can be presented to serve many uses.

Computer-Based Patient-Record Sys *CPR Sys: info-management tools to provide clinical reminders alerts, linkages with knowledge sources for health-care decision support, analysis of aggregate data for outcomes research improved management of healthcare delivery sys. *In a paper-based patient record, reader must manipulate data either mentally or on paper to glean important clinical info info. *A CPR sys provides computer-based tools to help

Comprehensiveness of info *Does CPR contain info about health as well as illness? *Does it include info from all clinicians who participated in a patient's care? *Does it cover all settings in which care was delivered (for EX, office practice, hospital)? *Does include full spectrum of clinical data, including, clinicians' notes, laboratory-test results, medication details, so on?

Benefits of CPR *Flexibility. *Displaying in different formats suitable for their interpretation. *Data can be used to *guide care for a single patient *help administrators develop policies for a population. *A CPR sys extends usefulness of patient data by applying info-management tools to data. Access: *In large organizations, traditional record may be unavailable to others for days while clinician finishes documentation of an encounter. *With computer-stored records, all authorized personnel can also access patient data immed ately as need arises. *Remote access to CPRs also is possible. Documenta-tion: *More legible in a CPR sys because it is recorded as printed textRather than as hand writing *Better organized because structure is imposed on input. *Improving quality by automatically applying validity checks on data as they are entered. *Typographical errors can be detected if a datum fails a reference range check. Data reuse: *Increases efficiency of provider's workflow. *Increases quality of data. More users uses that depend on a data element more likely that it will be element, reviewed be kept up date.

Duration of Use Retention of Data *A record that has accumulated patient data over 5 years will be more valuable than is one that contains records of only visits made during 1 month

Integrated View of Patient Data * growing volume of data for a patient from different sources *For EX, at present in United States, no national patient identifier (similar to a social security number) exists for linking patient data obtained from many sites *Although clinical data can be delivered to CPRs via **HL7**, a relatively mature message standard), differences among implementa-tions of HL7 must be resolved by interface engines engines. *Clinicians need more than just integrated access to patient data; they also need a specific **view** of patient data. ***Multiple Source-Data Syss that Contribute Patient Data *Quick Access to Summary Info about a Patient** patient's active medical problems, current medications, and drug allergies must keep in mind when making any decision on patient care. ***Tools to View Patient Data from Remote Sys *Tools to View Patient Data from Remote Syss**

Clinical Decision Support *Decision support is most effective when provided at time that physician is formulating her assessment of patient's condition is making ordering decisions. *Computer-assisted decision support is only acceptable when it allows physician to override a sys provided recom-mendation choose an alternative action. * most successful decision-support intervention makes complying with suggested action easy. ***Reminders Alerts**

Degree of Structure of Data *Medical data that are stored simply as narrative text entries will be more legible accessible than are similar entries in a paper medical record. *Uncoded info, however, is not standardized and inconsistent use of medical termino ogy limits ability to search for data. *Use of a controlled, predefined vocabulary facilitates automated aggregation summarization of data provided by different physicians or by same physician at different times. *Coded info is also required for computer-supported decision making clinical research

Disadvantages of CPR *It requires a larger initial investment due to HW, SW, training, support costs. *Key personnel may have to spend time away from their practice to learn how to use the sys to redesign their workflow to use the sys efficiently. *Physicians will also have to spend time learning how to use sys. Their workflow their interactions with their patients may change. *Converting from a paper-based medical record sys to a CPR involves substantial time, resources, determination, leadership. *Another risk associated with computer-based syss is potential for subtle as well as catastrophic failures. *If computer sys fails, stored info may be unavailable for an indeterminate time. *Paper records fail one chart at a time. *On other hand, if we consider that a given chart may be unavailable up to 30 percent of time, paper based sys may be considered to be down 30 percent of time for any given patient. *Organizations can take steps to decrease risk of CPR outages by providing backup *Physicians record large amounts of clinical info in their history, physical examination, progress notes. *Capture of this info directly from physician format is a major goal of medical informatics because it provides most timely, accurate, useful content. *However, time cost of physician input can be high, and many physicians resist use of computers to enter data. *Although new input devices are introduced or improved each year (for EX, pen-based entry, speech input), problems with convenience, portability, cost, and accuracy have made it difficult for these devices to compete with pen paper. *Dictation remains an option for data entry, but the turnaround time required for dictation to be transcribed, to review, correct, sign, file the transcribed document, creates delays. * lack of encoding further reduces benefits of using a CPR. *To avoid problem of data entry by physicians, some institutions have resorted to scanning physicians' notes into computer [Teich, 1997]. *Scanned documents do solve availability problems of paper chart because they can be retrieved and viewed from any computer device. *However, a typical scanned document occupies space; so delivery time can be slow, there is no option for searching or typically content of a scanned document without an abstraction step.

Functional Components of a Computer- Based Patient-Record Sys *A CPR is not simply an electronic version of paper record. * record is part of a comprehensive CPR sys, there are linkages tools available to facilitate commun cation & decision making. five functional components are *Integrated view of patient data *Clinical decision support *Clinician order entry *Access to knowledge resources *Integrated communication support

Ubiquity of access *A sys that is accessible from a few sites will be less valuable than one accessible from any computer by an authorized user

Clinician Order Entry *If ultimate goal of a CPR sys is to help clinicians make informed decisions, then sys should present relevant info at time of order entry*Several syss have capability of providing decision support during order-entry process* Clinical alerts attached to a laboratory-test result can also include suggestions for appropriate actions.*Providing summary info is another way of providing feedback to clinician when she is considering her orders. **EX: Clinical Alert** *Alerts can be attached to a laboratory-test result. Each time that a laboratory test is completed, a set of rules is checked to determine whether result is sufficiently abnormal to require further action. An essential feature of electronic medical records is their ability to use patient data in combination with protocols or algorithms to provide alerts reminders to clinical decision makers

Access to Knowledge Resources *Most queries of knowledge resources, whether they are satisfied by consulting another human colleague or by searching through reference materials or literature, are conducted in context of a specific patient. *Consequently, most effective time to provide access to knowledge resources is at time decisions or orders are being contemplated by clinician. *Furthermore, any method by which sys can provide preformatted queries that anticipate the clinicians' queries will be helpful will increase the chance that knowledge will influence clinicians' decisions. *Knowledge resources can also help a clinician to decide whether a referral is appropriate, and, if one is, which pre-consult tests may expedite consult process.

Integrated Communication Support *As care function becomes increasingly distributed among multidisciplinary health-care professionals, the effectiveness efficiency of communication among team members affect overall coordination and timeliness of care provided. *Most messages will be associated with a specific patient. *Thus, communic tion tools should be integrated with the CPR sys such that messages (including sys messages or laboratory-test results) are electronically attached to a patient's record. *That is, patient's record should be available at the touch of a button. *Geographic separation of team members creates the demand for networked communication that reaches all sites where providers make decisions on patient care. ***Communication as Part of Continuity of Care** Fundamental Issues for Computer-Based Patient-Record Syss * objectives of all medical-record syss are same, regardless of whether sys is automated or manual. * mechanism for accomplishing these objectives differ, however. *From a user's perspective, two approaches differ fundamentally in way data are entered into info is extracted from record. * issues alternatives related to data entry, displaying retrieving info from a computer-based medical record are explored. Fundamental Issues for Computer-Based Patient-Record Syss are ***Data Entry *Data Display *Query Surveillance Syss**

Data Entry * timely accurate transfer of patient info into computer is most difficult and labor-intensive step in maintenance of a computer-stored medical record. *Responsibility for entry of data into manual record is spread among many different health professionals. * transfer of data from its source to the computer requires two separate procedures: *1.data capture *If *scope* of medical record is restricted to the variables under control of organiza-tion maintaining record, **data capture** is straightforward. *Capture of comparable info across a patient's hospitalization, visit to emergency room, visit to a consulting physician in an independent practice is difficult. *Solutions require negoti tions with sites that frequently provide care to a practice's patients place extra work on part of practice * standards required to move data faithfully and automatically from source syss to CPRs within a health-care delivery is a significant challenge *2.data input * data-input step is burden-some because of personnel time required. *People must interpret or translate data, as well as enter them into computer. *Data may be entered in **free-text** form, in **coded** form, or in a form that combines both free text codes. * major advantage of coding is that data are classified standardized, thus facilitating selective retrieval of patient data, clinical research, administra-tive functions such as billing. * major disadvantage of coding is cost of translating source text into valid codes. *There also is potential for coding errors— which, in contrast to errors in free-text entry, are difficult to detect, because coded info lacks internal redundancy of text. *For EX, a transposition error causing a substitution of code for may not be detected unless computer displays the associated text data-entry operator notices error.

Tradeoffs between Use of Codes Narrative Text *Physicians can record complex info as narrative writing or dictation at speed of thought. * more detailed coding sys and more precisely they try to represent a complex description in code, slower and more costly coding effort becomes

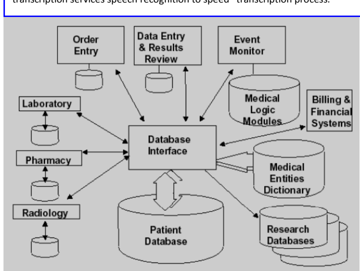
Coded Data *Immediate coding by physicians (best through-menu selection) yields codes thatCPR can use to guide physicians' decisions.*If menus are carefully designed, their use will be more accurate than coding by other personnel.*Various computer sources of coded data, including laboratory syss pharmacy syss &electrocardiogram (ECG) carts, exist in health-care settings. *Data from syss can flow automatically to CPR through message standards such as HL7.*challenge is variety of local coding syss. * solution is to use standard coding syss such as LOINC for identification of laboratory tests in United States) the National Drug Code for identific tion of drug products.

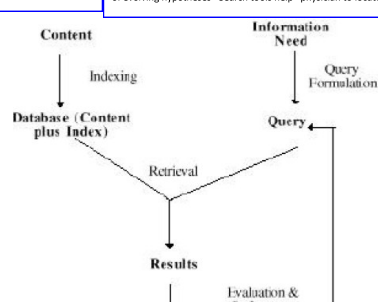
Error Prevention *Because of chance of transcription errors occurring when clinical info is entered into computer, CPR syss must apply **validity checks** scrupulously. A number of different kinds of checks apply to clinical data: ***Range checks** can detect or prevent entry of values that are out of range (for EX, a serum-potassium level of 50.0 meq/l— normal range for healthy individuals is 3.5 to 5.0 meq/l). ***Pattern checks** can verify that entered data have a required pattern (for EX, three digits, hyphen, and four digits of a local telephone number). ***Computed checks** can verify that values have the correct mathematical relationship (for EX, whiteblood- cell differential counts (reported as percentages) must sum to 100). ***Consistency checks** can detect errors by comparing entered data (for EX, recording of cancer of prostate as the diagnosis for a female patient). ***Delta checks** warn of large unlikely differences between values of a new result and of previous observations (for EX, a recorded weight that changes by 100 pounds in 2 weeks) ***Spelling checks** verify spelling of individual words. No such syntactic checks can catch all errors.

Physician-Entered Data Physicians record four kinds of info: *Patient histories *Physician's findings from physical examination *Physician's interpretation of patient's findings *Physician's diagnostic treatment plans Physicians' notes can be entered via one of three general mechanisms: *1.Transcription of dictated or written notes * recorded note must be played back in real time * requirement that author review, correct, sign note. *All these steps leave room for errors and delays in completing record *2.Entry of data recorded on structured encounter forms,* second data-entry method is to have physicians use a **structured encounter form** from which their notes are transcribed (and possibly encoded) by support personnel. *This approach has been most successful to date. *Some forms are highly tailored to capture coded info; *Some forms are tailored to specific patient problems. Encounter forms often contain checklists of common signs, symptoms, and diagnoses *3.Direct data entry by physicians* third alternative is **direct entry** of data, by a physician, via a computer. *Direct order entry can be facilitated by custom menus that contain standing orders for specific problems *Menus must be carefully structured: not contain lists that are too long, require scrolling, not impose a rigid hierarchy . *Direct entry of patient's history, physical findings, and progress notes has been challenging because of extra time it takes physician to enter such info into computer compared to a scribbled note. *Physicians who have adopted CPRs into their practice value benefits of immediate remote access to their patients' records consider initial data entry time worth benefits on retrieval side. ***Computer interpretation** of voice input holds promise to eliminate intermediate step of human transcription * speech recognition may eventually alleviate the problem of physician data entry, at least for narrative text,&that early implementations will combine transcription services speech recognition to speed transcription process.

Data Display *Data can be presented in numerous formats for different purposes without further entry work. *Computer-stored records can be produced in novel formats that are unavailable in manual syss. *A few helpful formats: *1.**Flow sheets of Patient Data***A **flow sheet** is similar to a spreadsheet. It organizes patient data according to time that they were collected, thus emphasizing changes over time. *For EX, a flow sheet used to monitor patients who have hypertension (high blood pressure) might contain values for weight, blood pressure, heart rate, doses of medications that control hypertension. *Flow sheets are designed to be problem specific, patient specific, or specialty specific. time granularity may change from one setting to *another. *For EX, when a patient is in intensive-care unit (ICU), minute-to-minute changes in patient's clinical state may be of interest. *2.**Summaries Abstracts***CPRs can highlight important components in smaller, more digestible reports. * usual strategy is to select specific classes of observation: active allergies, active problems, active treatments, recent observations. *In future, we can expect more sophisticated summarizing strategies, such as detection of significant changes in observations, or aggregation of abnormal observations with a similar meaning *We may also see reports that distinguish abnormal changes that have been treated from those that have not and displays that dynamically organize supporting evidence for existing problems. *Ultimately, computers should be able to produce concise and flowing summary reports that are like an experienced physician's hospital discharge summary. *3.**Turnaround Documents***Turnaround documents are computer-tailored reports that both present info to ask questions of the user. *In some settings, these forms are entered into the computer when completed. *A well-structured turnaround document allows direct capture of clinical info from physicians in many environments. *Paper turnaround documents are familiar materials and people can use them with little training. Direct input by clinicians into forms provided on a computer will soon replace most paper intermediaries. *4.**Dynamic dis-plays***Anyone who has reviewed a patient's chart knows how hard it can be to find a particular piece of info *Physicians do not find patient info that has been previously recorded belong in the medical record. *Furthermore questions clinicians routinely Furthermore, ask are often ones that are difficult to answer from perusal of a paper-based record. *Common questions include whether a specific test has ever been performed, what kinds of medications have been tried in past, and how patient has responded to particular treatments in past. *Physicians constantly ask these questions as they flip back forth in chart searching for facts to support or refute one in a series of evolving hypotheses *Search tools help physician to locate relevant data, specialized presentation formats make it easier for them to glean info from data.

Query Surveillance Syss * query surveillance capabilities of computer stored records have no counterpart in manual syss. *Medical personnel administrators can use these capabilities to generate alerts about important clinical events, to retrieve a patient's selected medical or administrative characteristics, to summarize info statistically. ***Query** is retrieval aggregation of data about groups of similar patients. ***Surveillance** across subgroups of patients is detection flagging of patient conditions that warrant medical attention.Query surveillance syss can be used for: *Clinical Care *Clinical Research *Retrospective Studies *Administration





$$\text{Recall} = \frac{\text{number of documents retrieved and relevant}}{\text{number of relevant documents in database}}$$

$$\text{Precision} = \frac{\text{number of documents retrieved and relevant}}{\text{number of documents retrieved}}$$

Management of Info in Integrated Delivery Networks Info Management in Health-Care Organizations *Health personnel require sufficient data &info management tools to make appropriate decisions *Caring for patients *Managing &running the environment, *Document &communicate plans &activities. *Medical directors evaluate the clinical outcomes of, quality of, &cost of health services provided. *Administrators determine appropriate staffing levels, manage inventories of drugs &supplies, &negotiate payment contracts for services. *Collectively, health-care professionals comprise a heterogen ous group with diverse objectives &info requirements.

Health-care Info sys (HCIS) *The purpose is to manage the info that health professionals need to perform their jobs effectively &efficiently. *HCISs facilitate communication, integrate info, &coordinate action among multiple health-care professionals.

Evolution from Hospital Info Systems to Health-Care Info Systems *1970s: hospital info sys (HIS) *1980s: *Departmental info systems such as laboratory &pharmacy systems * Clinical info sys offered clinically oriented capabilities, such as order writing &results communications. *Ambulatory medical record systems *Practice management systems were beingdeveloped to support large outpatient clinics &physician offices, respectively. *1990s: A large number of mergers &affiliations among previously independent &often competitive organizations *Major move to secure regional market share. *Hospitals &medical centers began to reach out tocommunity physician practices in an attempt to feed patient referrals to their specialty services &to fill their increasingly vacant inpatient beds. *Integrated health care chains &with other integrating organizations, hospitals banded into the regional health -care service providers called Integrated Delivery Networks (IDNs).

Relative Progress in Integration among 40 IDNs *Relative progress in structural, operational, clinical, &info integration among 40 IDNs from a 1996 survey of organizational members of the Center for Clinical Integration. *Clinical integration &info systems typically lag behind structural &operational integration in emerging IDNs.

Major organizational components of an integrated delivery network (IDN) *A typical IDN includes multiple acute-care facilities, ambulatory-care clinics, &owned or managed physicians' practices that jointly operate to provide comprehensive health services. *An IDN may own or affiliate with other healthcare facilities for-profit sub corporations care facilities, for corporations, managed care or health plan organizations. [HMO = Health Maintenance Organization.]

Integrated Delivery Networks *IDNs control a significant regional market share &are positioned to provide &manage comprehensive health services *IDNs negotiate service contracts with payors or directly with large employers. *Some IDNs go further &affiliate with a regional health maintenance organization (HMO) or develop their own health-plan organiz tions to act as their own insurance carriers. *The largest of the IDNs have pooled annual revenues of more than $1 billion, have staffs comprising or contract with thousands of physicians &nurses, &manage contracts to provide comprehensive care for more than 1 million patients.

Security &Confidentiality Requirements *The protection of health info is governed not only by the trust of patients in their health providers, but also, in most states, by law. The Benefits of Health-Care Info Systems *Cost Reduction *Quality &Service Improvement *Competitive Advantage Managing Info Systems in a Changing Health-Care Environment *Changing Technologies * Changing Culture Changing Process Functions &Components of a Healthcare Info Sys *Patient Management * Departmental Management * Care Delivery &Clinical Document tion * Clinical Decision Support * Financial &Resource Management Managed Care Support

Info Management *Info Requirement *Operational requirement: Health-care workers require detailed &up-to-date factual info to perform the daily tasks that keep a hospital, clinic, or physician practice running—the breadand- butter tasks of the institution. *Planning requirement: Health professionals also require info to make short- &long-term decisions about patient care &organizational management. *Documentation requirement: The need to maintain records for future reference or analysis makes up the third category of informational requirements. *Communication requirement: It should be clear that communication &coordination of patient care &operations across multiple personnel, multiple business units, &far-flung geography is not possible without investment in underlying technology infrastru ture. * Integration Requirement *Data integration: In hospitals, clinical &administrative personnel traditionally held distinct areas of responsibility &performed many of their functions separately. *Process integration: Health-care administrators have found the significant task agreements &task, reorganizing to achieve structural integration the easiest step in developing IDN.

Alternative Architectures for Health-Care Info Systems *Central Systems: *The earliest HCISs were central systems. *In this model a large, central computer serves the info needs of the entire hospital. *Users access the computer from video display terminals via general interface programs. * Modular Systems *In modular systems, much info processing is performed locally on dedicated machines that communicate with a central machine via direct interfaces. * Distributed Systems *Network technology that enables users to perform all info processing locally. *Independent machines share data over the network by passing messages according to a communication protocol.

Three Conceptual Layers of an IDN's Architectural Model *Separation of data, business logic, &user interface, allows sys developers to modify applications &interfaces over time to meet changing needs, while preserving the IDN's long-term data asset.

Future Directions for RIS (Computing Power) *Computers are an essential tool in radiology. *As processing power &storage have become less expensive, newer, computationally-intensive capabilities have been widely adopted. Future Directions for RI (Image Generation) *The overall trend with respect to image generation is ever-increasing numbers of imaging modalities; * Almost every modality provides unique information, so most of them will remain available. * For each modality, the trend is toward higher spatial, contrast, &temporal resolution, up to the physical limits. * Modalities will continue the trend toward three- or four dimensional data. New methods will continue to be found to image physiological function &modalities will be function, combined to maximize the info content. * Perhaps someday it will be possible to image the physiological activity of individual cells &even molecules within a living human body. Future Directions for RIS (Access) *Widespread access to images &reports will be demanded throughout health-care delivery networks, as access wider geographic areas for teleradiology services. *Methodology to build on the World Wide Web, augmented by Java for support of image-manipulation user interfaces. At the back end, systems will use distributed servers not only for storage &for connection to the patient's electronic medical record, but also for various kinds of image manipulation. * DICOM standard for format of image messages &HL7 messages, for clinical-data exchange. * Image retrieval will become much easier due to widespread use of controlled vocabularies such as the UMLS. Future Directions for RIS (Improved Speed & Software) *Images will be delivered via high-speed networks to increasingly powerful workstations equipped with commercially available software packages for image manipulation &visualization. * Sophisticated user interfaces will be combined with highlevel anatomical knowledge, often in the form of shapebased deformable models, to allow rapid creation of instantiations of the models to fit the image data for the given patient. * Three-dimensional instantiated models will provide a framework not only for visualizing &manipulating the three-dimensionalanatomy &pathology of individual patients, but also for superimposing non image info in a structure based visu l medical record. Future Directions for RIS (Interpretation) *Soft copy interpretation of radiology images will become common as user interfaces are improved &radiologists become comfortable with the process. * For reporting, continuous-speech recognition offers the best hope for an acceptable automated method of capturing radiologist interpretations. * Use of a combination of voice recognition for free text &for selecting phrases for structured reports will provide the best combination of methods, ultimately replacing dictation &transcription. Future Directions for RIS (Integration) *The radiology department systems in turn will be integrated with the enterprise health-info system of the IDN. *Thus, health-care personnel throughout an enterprise will have online access to the images, in addition to radiologists' reports. * At the same time, linkages between the RIS &patients' computer-based medical records will allow radiologists to access the clinical data that they need to interpret images &to obtain feedback on their work. * Other imaging-based specialties will also be integrated increasingly into the enterprise network, for distribution of their images &for tele-consulting.

The Radiologic Process &its Interaction Radiology departments are engaged in all aspects of the health-care process, *From diagnosis to treatment, *Acquiring &managing images, interpreting them, * Communicating those interpretations. * Interventional radiology &image-guided surgery are activities in which the radiologist plays a primary role in treatment.

Imaging Informatics *Recognition of the common issues that arise in all image modalities &applications once the images are converted to digital form. * Develop general solutions that can be applied to all images, regardless of the source. Common Tasks Studied by Imaging Informatics *Image integration. *Image Generatio *Spatial resolution [Pixel, Voxel] * Contrast resolution * Temporal resolution * Other parameters: *Magnitude of risk to the patient, * The degree of invasiveness, * The dosage of ionizing radiation, * The degree of patient discomfort, * The size (portability) of the instrument, * The ability to depict physiologic function as well as anatomic structure, &the cost of the procedure. *Image Manipulation *Image enhancement * Screening uses global processing, segmentation, feature detection, &classification to determine whether an image should be flagged for careful review by a radiologist or pathologist. *Quantitation * Thre dimensional reconstruction &visualization * Multimodality image fusion

Imaging SystemsRoles for Imaging in Health Care *Imaging is a central part of the health-care process for *Diagnosis * Assessment &Planning *Guidance of Procedures * Communication *Education &Training * Research Diagnosis * Light * Sound * Xray * *Isotope emissions * Energy fluctuations* of certain atomic Nuclei Assessment &Planning *In addition to being used for diagnosis, imaging is often used to assess a patient's health status, in terms of progression of a disease process (such as determination of tumor stage), response to treatment, &estimation of prognosis. Guidance of Procedures *Images can provide real-time guidance when virtual-reality methods are used to superimpose a surgeon's visual perspective on the appropriate image view in the projection that demonstrates the abnormality. Communication *Communicating digital images is essential to enable remote viewing, interpretation, &consultation, as in techniques such as tele-radiology, telepathology, &teledermatology, collectively referred to as dermatology, telemedicine. Education &Training *Images, both still &in motion form, are an essential part of medical education &training, because so much of medical diagnosis &treatment depends on imaging, &on the skills needed to interpret such images. Research *Imaging is, of course, also intimately involved in many aspects of research. *Structural modeling of DNA &proteins, including their three-dimensional configurations *Quantitative study of morphometrics, or growth &development, depends on the use of imaging methods. *Functional mapping— for example, of the human brain— relates specific sites on imagesto particular functions.

The Radiologic Process *Evaluation by a clinician of a clinical problem &determination of the need for an imaging procedure. *The procedure is requested &scheduled * The imaging procedure is carried out &images are acquired. * The radiologist reviews the images in terms of the clinical history &questions to be answered answered, &may manipulate the images. This task actually involves two subtasks (a) perception of the relevant findings &(b) interpretation of those findings in terms of clinical significance. * radiologist creates a report &may otherwise also directly communicate the results to the referring clinician * Quality control &monitoring are carried out, with the aim of improving the foregoing processes. Factors such as patient waiting times, workloads, numbers of exposures obtained per procedure, radiation dose, are measured &adjusted. * Continuing education &training are carried out through a variety of methods, including access to atlases, review materials, teaching-file cases, &feedback of subsequently confirmed diagnoses to interpreting radiologists.

Radiology Info Systems *The workings of a radiology department illustrate the many tasks in producing &managing clinical images. * Management of work flow in a radiology department is a complex activity that involves not only maint nance of the film library (&digital archive), but also scheduling of examinations, registration of patients, performance of examin tions, review &analysis of studies by radiologists, creation of interpretations, transcription of dictated reports (or generation of structured reports directly by radiologists), distribution of radiology reports to referring physicians, &billing for services. Radiology Info Systems *Client-Server distributed computing model * Voice Dictation System * Speech Recognizer * Transfer of patient demographic, billing, report, keep track of images with particular examination * Web interface * Radiation treatment planning

The Information-Retrieval Process
*(1) indexing,
*(2) query formulation,
*(3) retrieval,
*(4) evaluation &refinement

IR Process *The IR process starts with **indexing**, the process by which**content** (for example, bible graphic information, full-text journal articles) is represented &stored in a computer database. *An **IR database** typically contains both a shorthand representation of the content— an **index**— &the full original content. *The index allows users to find relevant content rapidly; the full content of the entries that the user selects is then displayed *There are many types of indexes, the simplest being an **inverted index**, which consists of items &item attributes. For example, we might create an inverted index of journal articles that discuss heart disease

Query Formulation *In parallel to indexing is **query formulation**: the process of stating information needs in terms of queries. *An **information need** is the searcher's expression, in her own language, of the information that she desires. *For example, a physician examining a 55 year-old man might think, Should middle-aged men be given a daily dose of aspirin to prevent heart attack?" *Because most search systems do not efficiently process natural-language expressions, an information need often must be translated into a statement composed in the language of the index: a **query**. *In our example, the query might be composed of individual items appearing in the index joined bycombin tion operators: "*aspirin AND prevention &heart &attack*."

Retrieval *Once an information need is represented in a query &content is represented in an index, the query can be compared against the index to produce results: a process, called **retrieval** ***Retrieval** includes matching queries against the index, ranking or sorting the output by some criteria, &displaying the results to the user. *For instance, retrieval using our query *aspirin &prevention &heart &attack*" &our index of journal articles would produce one document as the result.

Evaluation *The final step in the IR process is **evaluation**. *Results are inspected by the searcher and evaluated for relevance to the original information need. *If the search results are inadequate, the searcher may attempt to reword the query &to rematch against the index in a process called **refinement**. *The evaluation process also allows the comparison of different IR systems &techniques on the basis of a variety of metrics.

Evolution of Medical Information Retrieval *Retrieving information from medical sources have been in existence for over a century. *1879: Dr. John Shaw Billings created ***Index Medicus***to help medical professionals find relevant journal articles *1966: National Library of Medicine (NLM) developed an electronic version, the **Medical Literature Analysis &Retrieval System (MEDLARS) *MEDLARS: Medical Literature Analysis &Retrieval System** *Because computing power &disk storage were tightly limited, MEDLARS, as well as its follow on **MEDLARS Online (MEDLINE)**, stored only abstracted information from each article such as article, author names, article title, journal source, &publication date. *1980s: As computing power grew &disk storage became less expensive in the 1980s, full-text databases began to emerge. *These new databases allowed searching of the entire text of medical documents. *Although lacking graphics, images, &tables from the original source, these databases made it possible for users to retrieve the full text of important documents quickly, as well as from remote locations. *1990s: The advent of the World Wide Web (WWW or Web) &the exponentially increasing power of computers &networks, brought a world where vast quantities of medical information from multiple sources with various media extensions were now available over the global Internet

Information-Retrieval SystemsQuestions *What types of on-line content are available and useful to health-care professionals? *What are the three major steps in the information retrieval process? *How do techniques differ for indexing bibliographic versus full-text information? *How effectively do searchers utilize retrieval systems? *What challenges do the Internet and World Wide Web pose for information retrieval researchers? *How will changes in technology affect the scientific, economic, and political aspects of medical publishing?

Medical Information Retrieval *Medical informatics has traditionally concentrated on the retrieval of text from the biomedical literature. *The domain has broadened considerably with the advent of multimedia publishing &vast storehouses of chemical structures, cartographic materials gene &protein sequences video materials, sequences, clippings, &a wide range of other digital media of relevance to biomedical education, research, &patient care.

Indexing *The goal of indexing is to produce the smallest, most efficient representation of the original content that will facilitate high quality retrieval. ***Index items** are units of information suitable for matching with a query. *In contrast, **index attributes** describe facets of the item, such as the document numbers where the item appears, the frequency with which the item appears in a document or collection, or the position where the item is found relative to other items.

Content ***Content** can be defined as media developed to communicate information or knowledge. *Content can be separated into two categories: original &synoptic. ***Original content** is developed through new observations and analysis of the world. *Example: Medical journal articles that report original research *In contrast, authors develop **synoptic content** by extracting important observations &principles from sources of original content, as well as from personal experience. *Example: textbook, where experts, usually experts in their field, review &synthesize all available knowledge on a particular topic. ***Bibliographic content:** *abstracted* from the original source. As an example, bibliographic content derived from a collection of journal articles might include just the author names, article title, journal source, &publication date

Indexing of Bibliographic Information *MEDLINE is the world's premiere bibliographic information source. Developed by the National Library of Medicine (NLM), it contains references to 9 million biomedical journal articles published in 3500 journals since 1966

MEDLINE *MEDLINE is a highly structured source containing two types of information: *1. Information abstracted from the publication, such the author names, article title, article source, publication date, and author's abstract *2. Information added by a human indexer, such as subject headings &publication types

Medical Subject Headings (MeSH) *MeSH is a collection of over 18,000 **subject headings** grouped into one of 15 **trees** *MEDLINE uses MeSH to indicate the topics covered in each article. *Subject headings may have synonym forms, which are called **entry terms**. *Example: Hypertension

Indexing of Full-Text Information *Important words will appear a number of times &places within the full content, term frequency &term location can be used in the indexing method. ***Automated indexing** is the most common method of full-text indexing.

Automated indexing *It is sometimes called the **vector-space model**, because documents can be conceptualized as vectors of terms, with retrieval based on the cosine similarity of the angle between the query &document vectors. *The first step in doing automated indexing is extracting all words from the document that will be used for indexing. *High-frequency words that do not distinguish among documents, such as "*the*", "*and*", or "*that*", are eliminated. The remaining words are then **stemmed** to remove common suffixes, such as *s, es, ed, ing, al, &er*, and then are entered as items in the index. Stemming reduces word variants to a common form. *For example, the words *cough*, *coughs*, *coughed*, and *coughing*are all reduced to *cough*. *After word stems are identified, they are assigned weights that are based on their ability to discriminate among documents. *The term should help the system to differentiate relevant documents from non-relevant documents in the database. *Typically, words that are widely distributed across a database are not good discriminators, such as the words *diagnosis* or *treatment*. *Word stems that occur in only a small number of documents, however, are usually good discriminators.

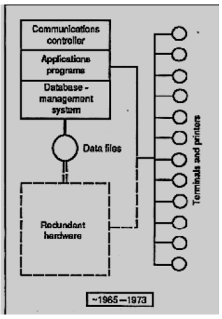
Weighting Measure
***Inverse Document Frequency (IDF):** how*in*frequently a term occurs in a document collection.
***Term Frequency (TF):** measures how frequently a term occurs in a document.

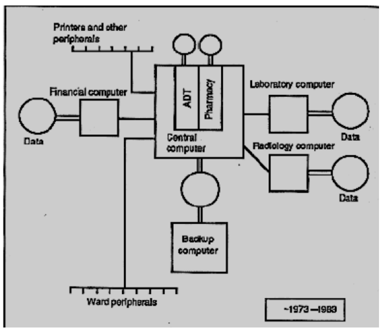
Query Formulation *There are two major modes of query formulation: *Boolean *Natural language Query Formulation *The usual **Boolean operators** are AND, OR, &NOT. *Most IR systems also have other features that assist the user in Boolean query formulation. All modern MEDLINE systems, for example, allow **text-word searching**, where the user can search on text words in the title &abstract. Query Formulation ***Natural-Language Queries** *An example of a natural language query is, "*Is carotidendarterectomy effective for prevention of stroke?*" *Processing steps can be divided into two categories: *(1) **syntactic**, or relating to the structure of words, phrases, or sentences, and *(2) **semantic**, or relating to the meaning of the words &phrases.

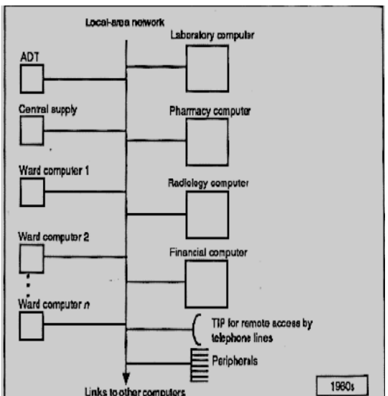
Retrieval *In **retrieval**, queries are compared against the index to create results. *The retrieval process comprises matching, ranking, &display. Matching *An algorithm to perform simple matching takes a term from the query &looks up that term in an index. *If there is a match between a query &an index item, the index attributes for the match are stored for later manipulation. Ranking *In the ranking process, the system ranks or sorts preliminary results by criteria to produce an ordered list of results. *The purpose of this ranking is to help users find the most relevant information quickly. *In many systems, the main ranking criterion is **chronology**; that is, the most recent entries are output first Display *The final step in the retrieval process is the display of ranked output to the user. *The entire content or parts thereof, rather than items or attributes from the index, usually is displayed

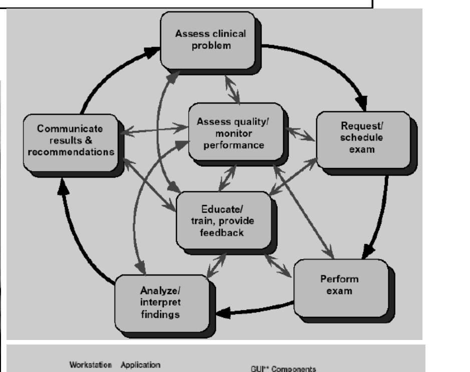
Evaluation *Evaluation of IR systems is important, not only for users who must judge the utility of their *searching, but also for system developers and researchers who want to better u derst&how to make them more effective. *A variety of questions can be asked: *Do they provide access to relevant information? Do they do it in a timely fashion? *Is the database being searched the appropriate one for the question at hand? ***Recall** is defined as the ratio of relevant documents retrieved to the total number of relevant documents in a database ***Precision** is the ratio of relevant documents retrieved to the total number of documents retrieved.

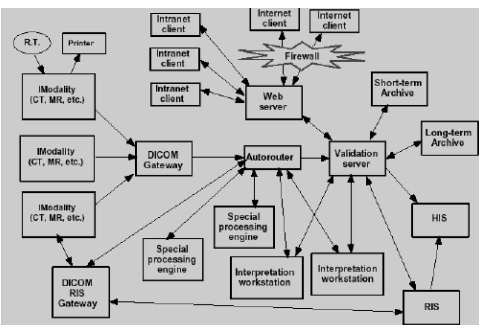
Problems **Context*: Words' meaning are affected by the meaning of other words around them. For example, the relatively common words *high*, *blood*, *&pressure*, take on added meaning when occurring together in the phrase *high blood pressure* as opposed to in the sentence, low *pressure*at *high* altitudes increases red *blood* cell count. **Polysemy*: The same word may have several different senses. For example, the word *lead* can represent the verb*to lead* the chemical *lead* or the electrocardiogram (ECG) machine *lead* that is connected to the patient. **Synonymy*: Different words may have the same meaning, such as *high &elevated*. This ambiguity may extend to phrases that have no words in common, such as the synonyms*hypertension &high blood pressure*. Problems **Granularity*: Queries &documents may describe concepts at different levels of a hierarchy. For example, a user might query for *antibiotics*to determine which of these drugs to use to treat a specific infection, whereas the documents might describe specific antibiotics themselves, such as *penicillin*. **Content*: Words in a document may not be the focus of a subject. For example, an article describing*hypertension* may mention in passing *congestive heart failure*.

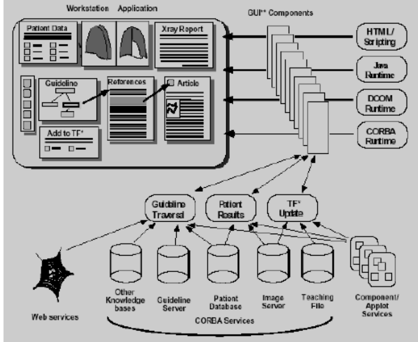












TF* = Teaching File; GUI** = Graphical User Interface