AMIA
INFORMATICS PROFESSIONALS. LEADING THE WAY.

3C Health Information Systems & Applications

Thomas H Payne, MD, FACMI, FAMIA
University of Washington

Clinical Informatics Board Review Course

Clinical Informatics Subspecialty Delineation of Practice (CIS DoP)

Domain 1: Fundamental Knowledge and Skills (no Tasks are associated with this Domain which is focused on fundamental knowledge and skills)

Clinical Informatics

K001. The discipline of informatics (e.g., definitions, history, careers, professional organizations)
K002. Fundamental informatics concepts, models, and theories
K003. Core clinical informatics literature (e.g., foundational literature, principle journals, critical analysis of literature, use of evidence to inform practice)
K004. Descriptive and inferential statistics
K005. Health Information Technology (HIT) principles and science
K006. Computer programming fundamentals and computational thinking
K007. Basic systems and network architectures
K008. Basic database structure, data retrieval and analytics techniques and tools
K009. Development and use of interoperability/exchange standards (e.g., Fast Health Interoperability Resources [FHIR], Digital Imaging and Communications in Medicine [DICOM])
K010. Development and use of transaction standards (e.g., American National Standards Institute X12)
K011. Development and use of messaging standards (e.g., Health Level Seven [HL7] v2)
K012. Development and use of ancillary data standards (e.g., imaging and Laboratory Information System[LIS])
K013. Development and use of data model standards
K014. Vocabularies, terminologies, and nomenclatures (e.g., Logical Observation Identifiers Names and Codes [LOINC], Systematized Nomenclature of Medicine --Clinical Terms [SNOMED-CT], RxNorm, International Classification Of Diseases[ICD], Current Procedural Terminology [CPT])
K015. Data taxonomies and ontologies
K016. Security, privacy, and confidentiality requirements and practices
K017. Legal and regulatory issues related to clinical data and information sharing
K018. Technical and non-technical approaches and barriers to interoperability
K019. Ethics and professionalism

The Health System

K020. Primary domains of health, organizational structures, cultures, and processes (e.g., health care delivery, public health, personal health, population health, education of health professionals, clinical research)
K021. Determinants of individual and population health
K022. Forces shaping health care delivery and considerations regarding health care access
K023. Health economics and financing
K024. Policy and regulatory frameworks related to the healthcare system
K025. The flow of data, information, and knowledge within the health system

Domain 2: Improving Care Delivery and Outcomes

K026. Decision science (e.g., Bayes theorem, decision analysis, probability theory, utility and preference assessment, test characteristics)
K027. Clinical decision support standards and processes for development, implementation, evaluation, and maintenance
K028. Five Rights of clinical decision support (i.e., information, person, intervention formats, channel, and point/time in workflow)
K029. Legal, regulatory, and ethical issues regarding clinical decision support
K030. Methods of workflow analysis
K031. Principles of workflow re-engineering
K032. Quality improvement principles and practices (e.g., Six Sigma, Lean, Plan-Do-Study-Act [PDSA] cycle, root cause analysis)
K033. User-centered design principles (e.g., iterative design process)
K034. Usability testing
K035. Definitions of measures (e.g., quality performance, regulatory, pay for performance, public health surveillance)
K036. Measure development and evaluation processes and criteria
K037. Key performance indicators (KPIs)
K038. Claims analytics and benchmarks
K039. Predictive analytic techniques, indications, and limitations
K040. Clinical and financial benchmarking sources (e.g., Gartner, Healthcare Information and Management Systems Society [HIMSS] Analytics, Centers for Medicare and Medicaid Services [CMS], Leapfrog)
K041. Quality standards and measures promulgated by quality organizations (e.g., National Quality Forum [NQF], Centers for Medicare and Medicaid Services [CMS], National Committee for Quality Assurance [NCQA])
K042. Facility accreditation quality and safety standards (e.g., The Joint Commission, Clinical Laboratory Improvement Amendments [CLIA])
K043. Clinical quality standards (e.g., Physician Quality Reporting System [PQRS], Agency for Healthcare Research and Quality [AHRQ], National Surgical Quality Improvement Program [NSQIP], Quality Reporting Document Architecture [QRDA], Health Quality Measure Format [HQMF], Council on Quality and Leadership [CQL], Fast Health Interoperability Resources [FHIR] Clinical Reasoning)
K044. Reporting requirements
K045. Methods to measure and report organizational performance
K046. Adoption metrics (e.g., Electronic Medical Records Adoption Model [EMRAM], Adoption Model for Analytics Maturity [AMAM])
K047. Social determinants of health
K048. Use of patient-generated data
K049. Prediction models
K050. Risk stratification and adjustment
K051. Concepts and tools for care coordination
K052. Care delivery and payment models

Domain 3: Enterprise Information Systems

K053. Health information technology landscape (e.g., innovation strategies, emerging technologies)
K054. Institutional governance of clinical information systems
K055. Information system maintenance requirements
K056. Information needs analysis and information system selection
K057. Information system implementation procedures
K058. Information system evaluation techniques and methods
K059. Information system and integration testing techniques and methodologies
K060. Enterprise architecture (databases, storage, application, interface engine)
K061. Methods of communication between various software components
K062. Network communications infrastructure and protocols between information systems (e.g., Transmission Control Protocol/Internet Protocol [TCP/IP], switches, routers)
K063. Types of settings (e.g., labs, ambulatory, radiology, home) where various systems are used
K064. Clinical system functional requirements
K065. Models and theories of human-computer (machine) interaction (HCI)
K066. HCI evaluation, usability engineering and testing, study design and methods
K067. HCI design standards and design principles
K068. Functionalities of clinical information systems (e.g., Electronic Health Records [EHR], Laboratory Information System [LIS], Picture Archiving and Communication System [PACS], Radiology Information System [RIS] vendor-neutral archive, pharmacy, revenue cycle)
K069. Consumer-facing health informatics applications (e.g., patient portals, mobile health apps and devices, disease management, patient education, behavior modification)
K070. User types and roles, institutional policy and access control
K071. Clinical communication channels and best practices for use (e.g., secure messaging, closed loop communication)
K072. Security threat assessment methods and mitigation strategies
K073. Security standards and safeguards
K074. Clinical impact of scheduled and unscheduled system downtimes
K075. Information system failure modes and downtime mitigation strategies (e.g., replicated data centers, log shipping)
K076. Approaches to knowledge repositories and their implementation and maintenance
K077. Data storage options and their implications
K078. Clinical registries
K079. Health information exchanges
K080. Patient matching strategies
K081. Master patient index
K082. Data reconciliation
K083. Regulated medical devices (e.g., pumps, telemetry monitors) that may be integrated into information systems
K084. Non-regulated medical devices (e.g., consumer devices)
K085. Telehealth workflows and resources (e.g., software, hardware, staff)

Domain 4: Data Governance and Data Analytics

K086. Stewardship of data
K087. Regulations, organizations, and best practice related to data access and sharing agreements, data use, privacy, security, and portability
K088. Metadata and data dictionaries
K089. Data life cycle
K090. Transactional and reporting/research databases
K091. Techniques for the storage of disparate data types
K092. Techniques to extract, transform, and load data
K093. Data associated with workflow processes and clinical context
K094. Data management and validation techniques
K095. Standards related to storage and retrieval from specialized and emerging data sources
K096. Types and uses of specialized and emerging data sources (e.g., imaging, bioinformatics, internet of things (IoT), patient-generated, social determinants)
K097. Issues related to integrating emerging data sources into business and clinical decision making
K098. Information architecture
K099. Query tools and techniques
K100. Flat files, relational and non-relational/NoSQL database structures, distributed file systems
K101. Definitions and appropriate use of descriptive, diagnostic, predictive, and prescriptive analytics
K102. Analytic tools and techniques (e.g., Boolean, Bayesian, statistical/mathematical modeling)
K103. Advanced modeling and algorithms
K104. Artificial intelligence
K105. Machine learning (e.g., neural networks, support vector machines, Bayesian network)
K106. Data visualization (e.g., graphical, geospatial, 3D modeling, dashboards, heat maps)
K107. Natural language processing
K108. Precision medicine (customized treatment plans based on patient-specific data)
K109. Knowledge management and archiving science
K110. Methods for knowledge persistence and sharing
K111. Methods and standards for data sharing across systems (e.g., health information exchanges, public health reporting)

Domain 5: Leadership and Professionalism

K112. Environmental scanning and assessment methods and techniques
K113. Consensus building, collaboration, and conflict management
K114. Business plan development for informatics projects and activities (e.g., return on investment, business case analysis, pro forma projections)
K115. Basic revenue cycle
K116. Basic managerial/cost accounting principles and concepts
K117. Capital and operating budgeting
K118. Strategy formulation and evaluation
K119. Approaches to establishing Health Information Technology (HIT) mission and objectives
K120. Communication strategies, including one-on-one, presentation to groups, and asynchronous communication
K121. Effective communication programs to support and sustain systems implementation
K122. Writing effectively for various audiences and goals
K123. Negotiation strategies, methods, and techniques
K124. Conflict management strategies, methods, and techniques
K125. Change management principles, models, and methods
K126. Assessment of organizational culture and behavior change theories
K127. Theory and methods for promoting the adoption and effective use of clinical information systems
K128. Motivational strategies, methods, and techniques
K129. Basic principles and practices of project management
K130. Project management tools and techniques
K131. Leadership principles, models, and methods
K132. Intergenerational communication techniques
K133. Coaching, mentoring, championing and cheerleading methods
K134. Adult learning theories, methods, and techniques
K135. Teaching modalities for individuals and groups
K136. Methods to assess the effectiveness of training and competency development
K137. Principles, models, and methods for building and managing effective interdisciplinary teams
K138. Team productivity and effectiveness (e.g., articulating team goals, defining rules of operation, clarifying individual roles, team management, identifying and addressing challenges)
K139. Group management processes (e.g., nominal group, consensus mapping, Delphi method)

Knowledge Statements from the DoP

K060 Enterprise architecture (databases, storage, application, interface engine)

K061 Methods of communication between various software components

K062 Network communications infrastructure and protocols between information systems (e.g., TCP/IP, switch, routers)

K063 Types of settings (e.g., labs, ambulatory, radiology, home) where various systems are used

K068. Functionalities of clinical information systems (e.g., Electronic Health Records [EHR], Laboratory Information System [LIS], Picture Archiving and Communication System [PACS], Radiology Information System [RIS] vendor-neutral archive, pharmacy, revenue cycle)

K085 Telehealth workflows and resources (e.g., software, hardware, staff)

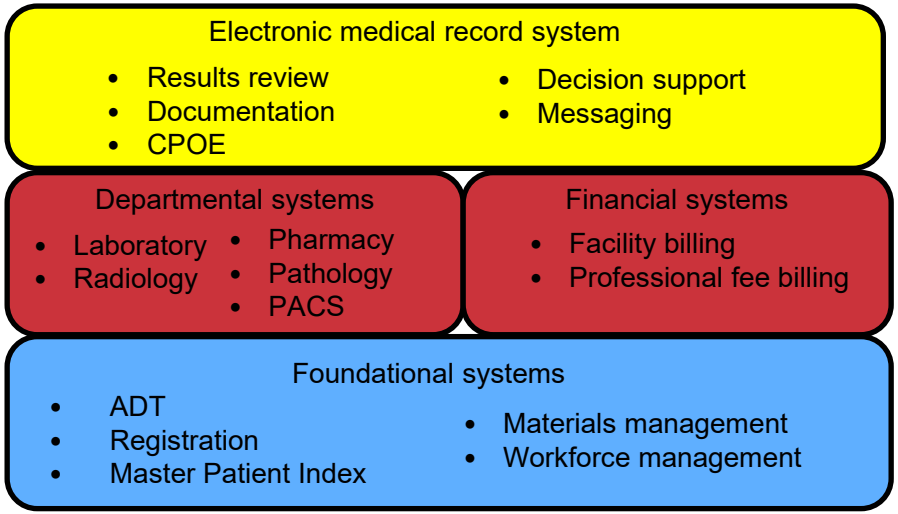
Key topics

Architecture, technical and computing infrastructure underlying health information systems (HIS).

Breadth of HIS functionality and topics historically challenging to physicians.

Telemedicine application areas and types.

Examples of clinical computing system functionality commonly used



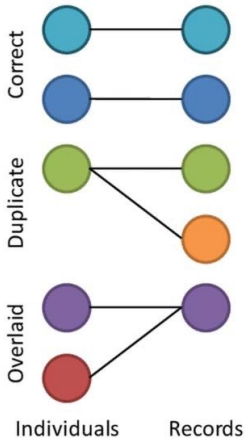
Master Patient Index

Definition: An electronic database that holds demographic information on every patient who receives healthcare services. The MPI aims to accurately match and link records by uniquely identifying individuals.

Methods for matching:

- Deterministic (sometimes called exact match logic)
- Probabilistic (recognizes variability, Robert vs Bob)

Goal is to avoid *duplicate* and *overlaid* records.



colleaga.org

Departmental systems

Laboratory
- Clinical pathology
- Anatomic pathology
- Blood bank

Radiology
- PACS
- RIS

Pharmacy
- Unit dose
- Retail

Cardiology (ECG, echo, cath, PACS)

Dietary

Neurology (EMG, NCV)

Pulmonary (PFT)

GI endoscopy

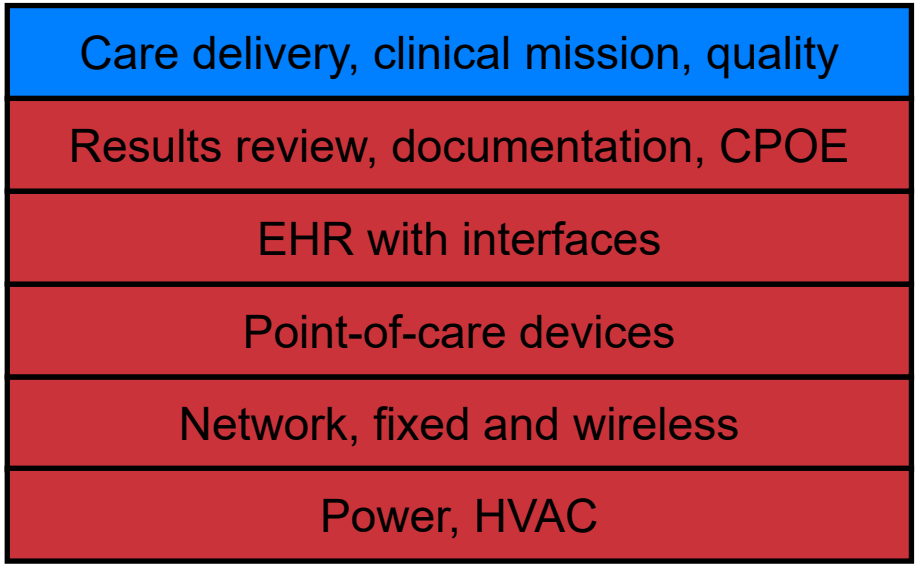
Financial systems

Facility fee

Professional fee

Financial and strategic decision support

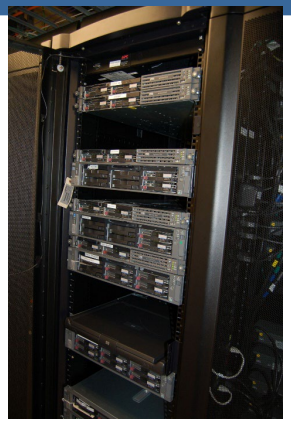
Layers of infrastructure



Infrastructure – Physical

Data Center is a dedicated and protected facility with specific requirements of electricity, humidity, and air conditioning

- Usually one per campus or institution
- Houses hundreds of servers, appliances, and disk storage
- These are placed on racks, and are physically measured in “rack units”
- Physically protected, electrically fed



Slide courtesy of Soumitra Sengupta

Data Center Classes

Tier I (Basic) - Single path for power and cooling distribution, without redundancy (99.671% availability).

Tier II (Redundancy) - Single path for power and cooling distribution (99.741% availability).

Tier III (Concurrently maintainable) - Multiple active power and cooling paths, but only one path active; has redundancy (99.982% availability).

Tier IV (Fault tolerant) - Multiple active power and cooling distribution paths; has redundancy (99.995% availability).

From: Turner, Seader, and Brill. The Uptime Institute (https://uptimeinstitute.com/research-publications/asset/tier-standard-topology)

Slide courtesy of Dave Chou

The most accurate statement regarding health IT infrastructure is:

A. UPS provide electrical power for the duration of most power outages.

B. The phrase “dual-homed” indicates routers connect to both fiber and wire cabling.

C. Cloud storage is inherently less secure than local storage.

D. Data center protections for power and cooling can be considered security measures.

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C. Cloud storage is inherently less secure than local storage.

D. Data center protections for power and cooling can be considered security measures.

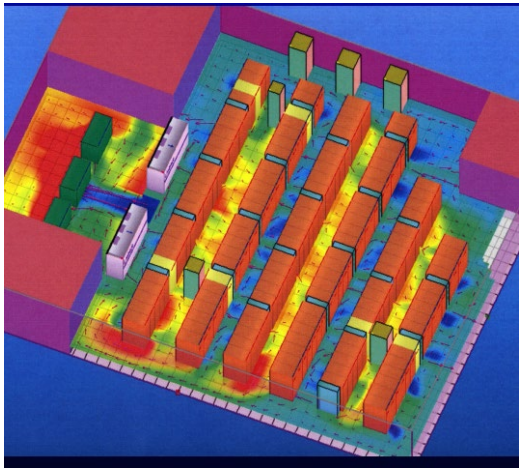
ANSWER: D. Loss of power and cooling may prevent access of users to data they need. Not A: UPS powers till generator up. Not B: “dual homed” means 2 network interfaces. Not C: storage security depends on policy and technical features

Infrastructure – Physical – Data Center issues

- Uninterruptible Power Supplies (UPS) provide 30 minute of backup power using storage batteries to be replaced every 3-5 years
- A fully loaded rack may weigh 2000lbs. 100 racks require ensuring proper structural integrity
- Too many physical servers and other equipment → Virtualization

Slide courtesy of Soumitra Sengupta

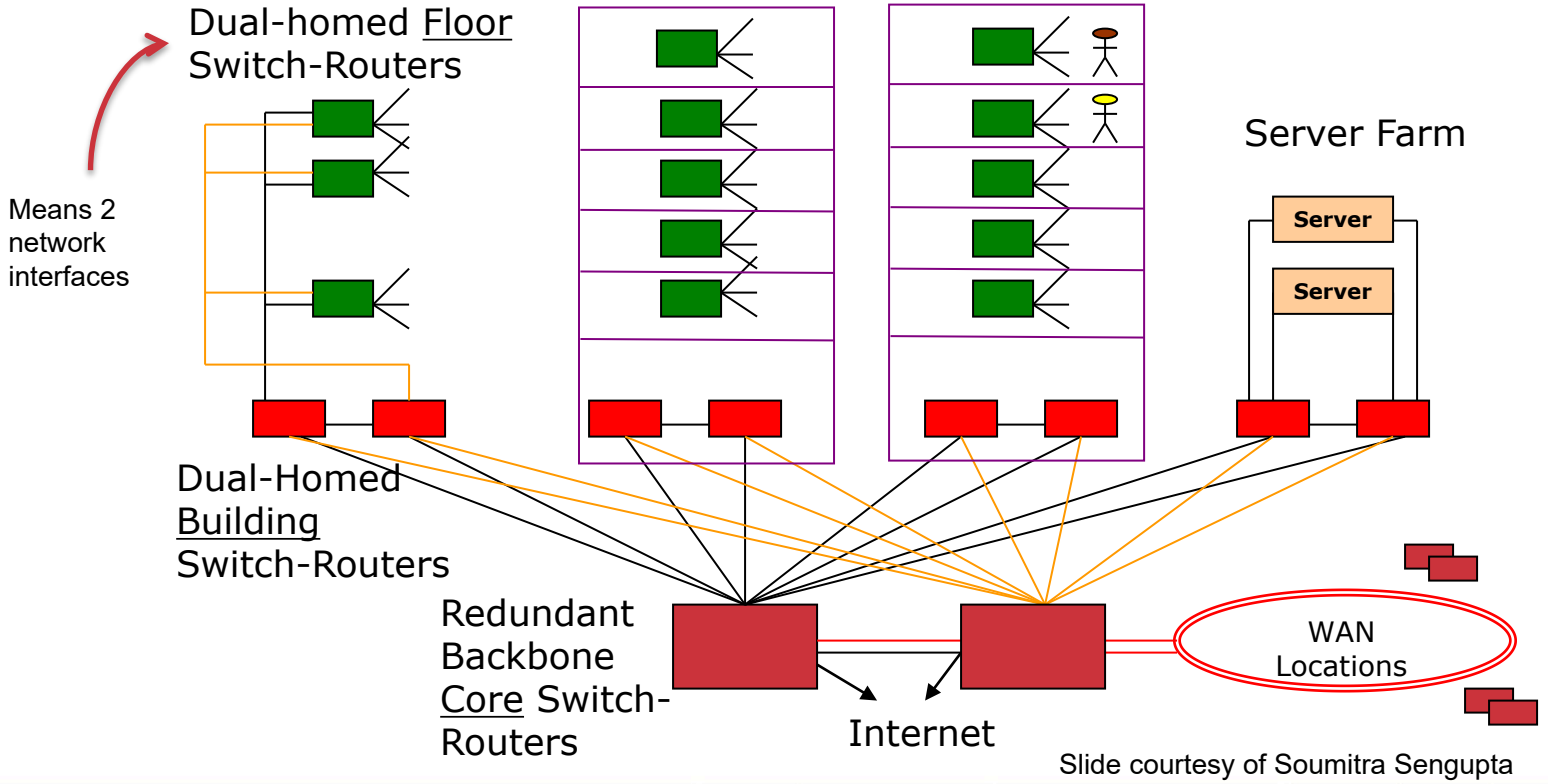
Infrastructure Physical – Data Center issues



- Expensive to build, hence often outsourced where space and electricity are cheaper
- Redundancy in air conditioning, power, networking
- Heat– A fully loaded rack could consume 20kw, and require 6 tons of cooling. 100 racks require 2Mw electricity, and may need water-cooled air conditioning

Slide courtesy of Soumitra Sengupta

Infrastructure – Network design



Slide courtesy of Soumitra Sengupta

International Organization for Standardization Open Systems Interconnection model

OSI Model			
Layer		Protocol data unit (PDU)	Function[3]
Host layers	7. Application	Data	High-level APIs, including resource sharing, remote file access
	6. Presentation		Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption
	5. Session		Managing communication sessions, i.e. continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes
	4. Transport	Segment (TCP) / Datagram (UDP)	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing
Media layers	3. Network	Packet	Structuring and managing a multi-node network, including addressing, routing and traffic control
	2. Data link	Frame	Reliable transmission of data frames between two nodes connected by a physical layer
	1. Physical	Bit	Transmission and reception of raw bit streams over a physical medium

Wikipedia

In the ISO/OSI model, TCP/IP can be considered at what levels?

A. 1 and 2

B. 2

C. 3 and 4

D. 4

In the ISO/OSI model, TCP/IP can be considered at what levels?

A. 1 and 2

B. 2

C. 3 and 4

D. 4

ANSWER: C. We showed the ISO/OSI model. In this model, TCP/IP is represented using both levels 3 and 4. Not layer 1: this is the physical layer (e.g., copper, fiber) Not layer 2, which covers network access

Infrastructure – Physical – Cabling

Data closet is a smaller space, typically on each floor, which houses networking equipment and cable ends

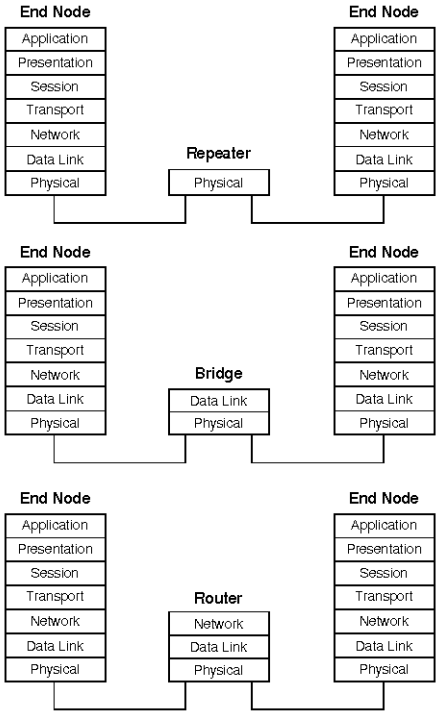
- Standards - IEEE

Cable plant is a topographical layout of physical cables connecting desktops to the equipment in the closets and cables interconnecting closets and the data center.

- Standards

Slide courtesy of Soumitra Sengupta

Router, Switch, Hub



OSI Model	DoD Model	protocols		devices/apps
layer 5, 6, 7	application	dns, dhcp, ntp, snmp, https, ftp, ssh, telnet, http, pop3... others		web server, mail server, browser, mail client...
layer 4	host-to-host	tcp	udp	gateway
layer 3	internet	ip, icmp, igmp		router, firewall layer 3 switch
layer 2	network access	arp (mac), rarp		bridge layer 2 switch
layer 1		ethernet, token ring		hub

Which of the following accurately describes increasing complexity of these network devices?

A. Bridges are simpler than hubs

B. Routers are simpler than switches

C. Bridges are more complex than switches

D. Routers are more complex than hubs

Which of the following accurately describes increasing complexity of these network devices?

A. Bridges are simpler than hubs

B. Routers are simpler than switches

C. Bridges are more complex than switches

D. Routers are more complex than hubs

ANSWER: D. Listed in order of increasing complexity: Hub, bridge, switch, router

Infrastructure – Physical cabling issues

- Closets may not have adequate HVAC
- Cables are laid, old ones are almost never taken out – a weight issue
- Fire codes must be followed going across floors and buildings
- New cables in ICU and OR require utmost caution
- Cables can be outdated, unable to support higher bandwidth
- Labor costs of cabling outweighs other hardware and software purchases
- Security of closets and cables are suspect; closets may be shared

Architecture terminology

Client Server

- Desktop clients handle user interaction. More powerful servers handle data requests

Application Service Provider(ASP) model

- Business that provides computer services over the internet

Remotely hosted

- Data under the control of a third party owner of the servers where the data are stored

Cloud computing (covered in 3E1-2)

- The provision of dynamically scalable and often virtualized resources as a service over the Internet on a utility basis (Wikipedia)

Health Information System Archetypal Architectures

Integrated systems: Those in which patient data exist in the same database used by all clinical applications.

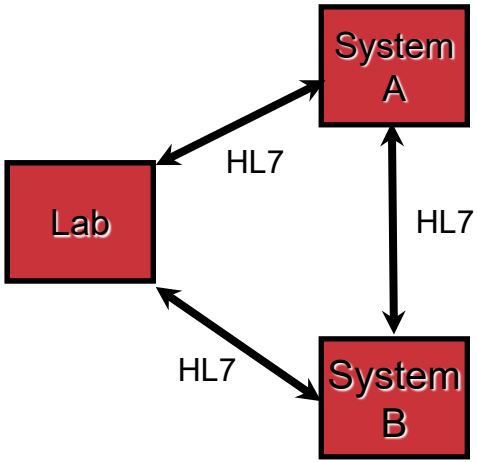
Interfaced systems: Those in which data are communicated between separate applications with different databases, usually by means of an interface using HL7 protocol.

"Best of breed"

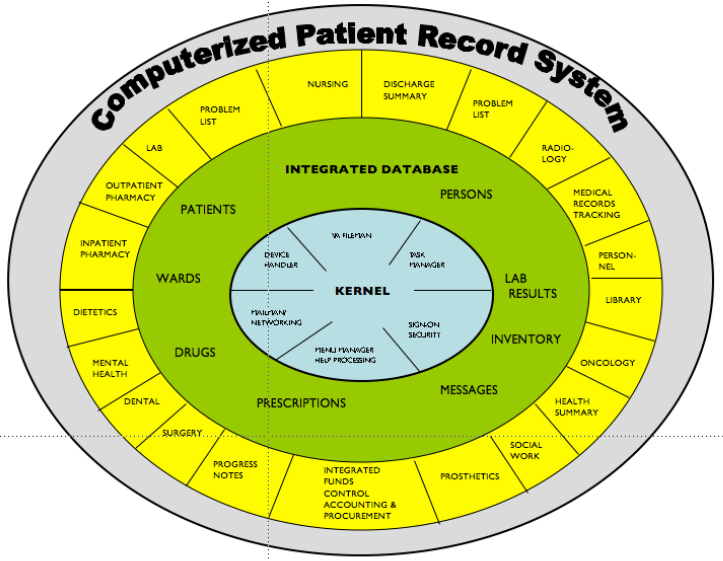
In practice most organizational clinical computing systems are a mixture, with varying degrees of both.

Archetypal architectures

Interfaced



Integrated



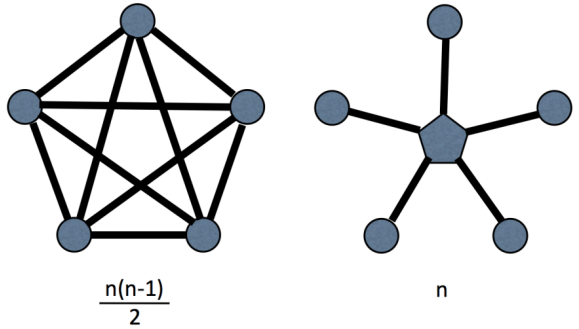
Adapted from Andrus RW. Integrating a Clinical System. In Kolodner RM, ed. Computerizing Large Integrated Health Networks. The VA Success. New York: Sprinter-Verlag, 1997.

Interface engines

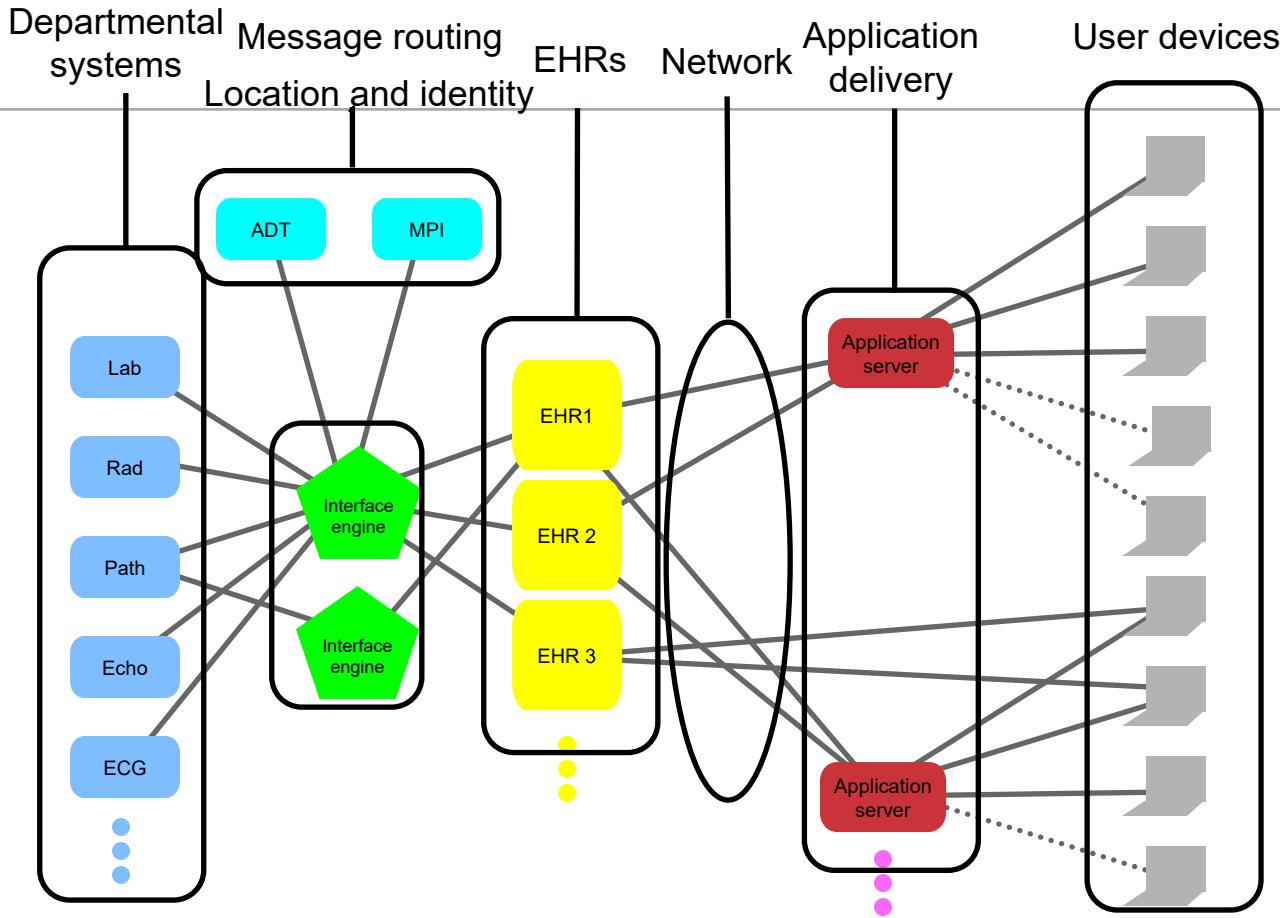
An Interface Engine (a.k.a. message broker, application-level router) is a middleware application used to transform, route, clone and translate messages. A HL7 interface engine is an interface or integration engine built specifically for the healthcare industry. [HL7]

Can “play back” messages when unavailable receiving system comes back online.

Useful, common, fallible.



This formula demonstrates potential reduction in point-to-point interfaces


Departmental systems
Message routing
Location and identity
EHRs
Network
Application delivery
User devices
ADT
MPI
Lab
Rad
Path
Echo
ECG
Interface engine
Interface engine
EHR1
EHR 2
EHR 3
Application server
Application server

Examples of component failures and their clinical consequences

Component	Problems	Clinical consequence
MPI	Application failure	Newly enrolled patients not transmitted to departmental systems and EHR; patient misidentification
Power and HVAC	Loss of power or environmental controls	Shutdown of all hosts in affected room, major outage
Network hubs, routers, switches, fiber, cables	Denial of service attack, spanning tree problems, cable disruption	Local or widespread unavailability of applications
Interface engine	Application failure	New results and MPI information not transmitted to departmental systems preventing new results, orders
Departmental applications	Failure of disks, controllers, application or operating system	New clinical data generated by department not available
Repository and EHR	Database corruption, application failure, faulty patch or upgrade	Impaired performance or application unavailability
Terminal server	Memory leaks, host failure	Partial or widespread loss of access to EHR
Workstations	Misconfiguration, local drive failure, virus	Partial or widespread loss of access to EH

Methods to improve interoperability between HIT systems

1. Interfaces (HL7, other)
2. Communicate results in paper; scan into foreign EHR
3. Reciprocal access
4. Embedded applications
5. Context sharing—CCOW (Clinical Context Object Workgroup), other
6. Build separate application with data from both
7. Vendor mediated EHR content sharing

Types of settings where various systems are used

- Ambulatory
  - Clinic
  - Free standing surgical center
  - Emergency room
  - Infusion center
  - Dialysis center
  - Operating room
  - Skilled nursing facility (SNF)
  - Long-term acute care facility (LTAC)
  - Home
- Inpatient
  - Acute care
  - Psychiatry
  - Rehabilitation service
  - ICU
    - Trauma/surgical
    - Pulmonary Medicine
    - Cardiology
    - Neurology/neurosurgery
    - Neonatal
    - Remote ICU
- Departmental
  - Anatomic pathology
  - Clinical laboratory
  - Radiology
  - Pulmonary function lab
  - Cath/EP lab

Electronic health/medical record systems as the foundational tool

- Evolution from department-focused to patient-focused
  - Tab metaphor for data remains common
- Goal of problem-oriented medical record remains largely elusive
- Most visible system to clinicians and patients
- Target of federal incentive programs

Electronic health record functionality
[IOM 2003]

Box 2. Core Functionalities for an Electronic Health Record System

Health information and data	Patient support
Results management	Administrative processes
Order entry/management	Reporting & population health management
Decision support	
Electronic communication and connectivity	

IOM Committee on Data Standards for Patient Safety, 2003
https://www.nap.edu/read/10781/chapter/2#6

EHR functionality. 1

Message box (proprietary names vary but functionality similar)

Results review (lab, path, imaging, notes)

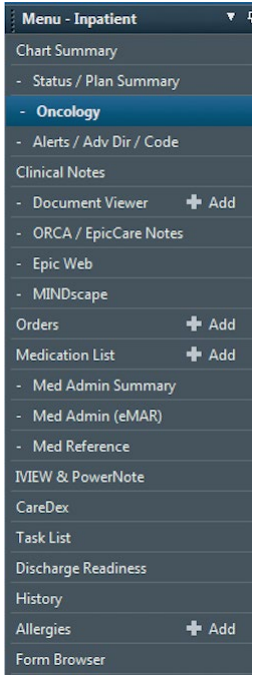
Documentation (direct entry, structured/unstructured, dictation, mixed)

Order management

Patient summary displays

Medication administration record

- Bar code medication administration



EHR functionality. 2

Patient lists, schedule, rounding/handoff tools

Patient monitoring review

Quality metrics, dashboards

Billing

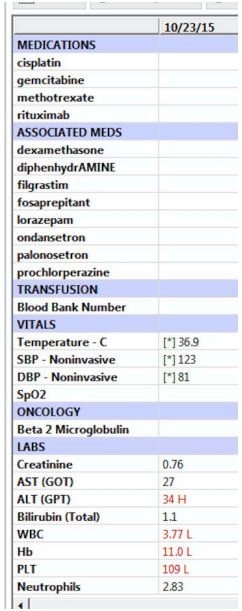
- Professional fee
- Facility fee

Patient support

Administrative

Electronic communication

- With team
- With patients



	10/23/15
MEDICATIONS	
cisplatin	
gemcitabine	
methotrexate	
rituximab	
ASSOCIATED MEDS	
dexamethasone	
diphenhydrAMINE	
filgrastim	
fosaprepitant	
lorazepam	
ondansetron	
palonosetron	
prochlorperazine	
TRANSFUSION	
Blood Bank Number	
VITALS	
Temperature - C	[*] 36.9
SBP - Noninvasive	[*] 123
DBP - Noninvasive	[*] 81
SpO2	
ONCOLOGY	
Beta 2 Microglobulin	
LABS	
Creatinine	0.76
AST (GOT)	27
ALT (GPT)	34 H
Bilirubin (Total)	1.1
WBC	3.77 L
Hb	11.0 L
PLT	109 L
Neutrophils	2.83

EHR functionality. 3

Population health

External resources

Aspects of all functionality:

- Compliance
- Decision support

The HIMSS EHR Adoption Model:

A. Lists population health in Stage 7

B. Is directly incorporated into Meaningful Use

C. Lists 7 stages of EHR adoption

D. Does not describe steps in adoption for many hospitals.

The HIMSS EHR Adoption Model:

A. Lists population health in Stage 7

B. Is directly incorporated into Meaningful Use

C. Lists 7 stages of EHR adoption

D. Does not describe steps in adoption for many hospitals.

Answer: D. Hospitals may very reasonably adopt functionality in different steps suited to their circumstances.
Not A—population health is not mentioned.
Not B—this model is not mentioned in MU.
Not C—there are 8 levels, starting with 0.

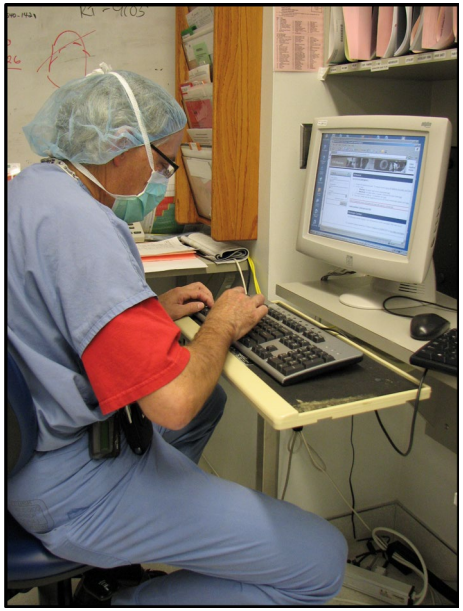
HIMSS EHR Adoption Model

STAGE	HIMSS Analytics EMRAM EMR Adoption Model Cumulative Capabilities
7	Complete EMR; External HIE; Data Analytics, Governance, Disaster Recovery, Privacy and Security
6	Technology Enabled Medication, Blood Products, and Human Milk Administration; Risk Reporting; Full CDS
5	Physician documentation using structured templates; Intrusion/Device Protection
4	CPOE with CDS; Nursing and Allied Health Documentation; Basic Business Continuity
3	Nursing and Allied Health Documentation; eMAR; Role-Based Security
2	CDR; Internal Interoperability; Basic Security
1	Ancillaries - Laboratory, Pharmacy, and Radiology/Cardiology information systems; PACS; Digital non-DICOM image management
0	All three ancillaries not installed

Documentation using EHRs

4 factors influence satisfaction with electronic documentation tools:

1. Time efficiency
2. Availability/accessibility
3. Expressivity
4. Quality



[Rosenbloom 2007]

Issues to confront

1. Time spent writing notes (4-14 min per, Mamykina 2012)
2. “Electronic notes are harder to understand.”
3. Copying and pasting
4. Time spent writing notes
5. Note loss, notes in wrong chart, notes with wrong title, notes on wrong encounter
6. Billing and compliance

Study on copying & pasting in an EHR

Copying and pasting severity scale

1. Artifact, not misleading, no risk
2. Artifact, minimally misleading, minimal risk
3. Human, not misleading, no risk
4. Human, minimally misleading, minimal risk
5. Human, misleading, some risk
6. Human, clinically misleading, major risk

[Hammond 2003]

Accuracy of automatic speech recognition

Reported percentage of documents with errors ranged from 4.8% to 71%; reported word error rates ranged from 7.4% to 38.7%.

Accuracy rising over time in opinion of most medical users.

[Blackley 2019]

Conclusions from Hammond study

One in ten electronic charts contained an instance of high-risk copying.

Clear policies, practitioner consciousness-raising and development of effective monitoring procedures are recommended to protect the value of electronic patient records.

Outpatient Visit Note, 10/16/01	Student Note, 5/30/02
VITALS: BP:136/73 HR:80 Wt:246.4 lb PN 2/10 rt heel S. 57 year old RTC to p/u new FFO. Pt complains of heel pain rt only subsideing slowly with new orthoses; PMH: PTSD, depressing, GERD 79 pack years, quit smoking three years ago. Currently sober & for THE PAST 3+ years O- Vasc: DP/PTpalable b/l, TTT intact b/l Neuro: Semes weinstein 5.07/10g monofilament wire sensation intact b/l epicratic sensation intact b/l Derm: toenails l-5 b ft thickwened brittle incurvated painful with yelow subungual debris distal 1/3 only Musc: strenght intact, ROM intact FLEXIble PES cavus B/L Flexible hammertoes b/l Pinpoint pain with palpable medial heel r only A. 1. Plantar fasciitis r>l CHRONIC 2. B/l PES cavus 3. onychomycosis 1-5 b ft P. continue FOOTMAXX FFO rtc May 02 renew naprosyn 2 tabs bid # 120	VITALS: 05/30/2002 08:55 BP:127/63 HR:72 Wt:255 lb [115.9 kg] S. 57 year old RTC to p/u new FFO. Pt complains of heel pain rt only subsideing with new orthoses; Pt cont to take the naproxen for pain relief. Pt states clotrimazole soln is working well for toenail fungus. PMH: PTSD, depressing, GERD 79 pack years, quit smoking three years ago. Currently sober & for THE PAST 3+ years O- Vasc: DP/PT palable b/l, TTT intact b/l Neuro: Semes weinstein 5.07/10g mono-filament wire sensation intact b/l epicratic sensation intact b/l Derm: toenails l-5 b ft thickwened brittle incurvated painful with yelow subungual debris distal 1/3 only Musc: strenght intact, ROM intact FLEXIble PES cavus B/L Flexible hammertoes b/l Pinpoint pain with palpable medial heel r only A. 1. Plantar fasciitis r>l CHRONIC 2. B/l PES cavus 3. onychomycosis1-5 b ft P. continue FOOTMAXX FFO cont naproxen, cont clotrimazole soln rtc Aug 02 to be rescanned for new footmax ffos Pt and tx d/w Dr. XXXX.

Figure 1. Marked-up progress note showing copied text (and rated "Human, clinically misleading, major risk").

[Hammond 2003]

Documentation tools

Click in a template

Mixture of click and type

Type in a text editor

Hybrid dictation

Dictation

Structured

Age: 53
Gender: M

Problems: HEART FAILURE, UNSPECIFIED [428.9]
ROS: Dyspnea [267036007]

Chest pain [29857009]

Unstructured

"This 53 y.o. male with congestive heart failure presents with dyspnea, chest pain…"

Definition of CPOE

Computerized practitioner order entry is defined as a process which allows the ordering practitioner to use a computer to directly enter medical orders.

Reduction in serious medication errors

	Phase 1 Rate (Events/1000 Patient-Days, Mean)	Phase 2 Rate (Events/1000 Patient-Days, Mean)	% Difference	*P*
Nonintercepted serious medication errors	10.7	4.86	-55	.01
Preventable ADEs	4.69	3.88	-17	.37
Nonintercepted potential ADEs	5.99	0.98	-84	.002
All ADEs	16.0	15.2	-5	.77
Nonpreventable ADEs	11.3	11.3	0	.99
All potential ADEs	11.7	3.38	-71	.02
Intercepted potential ADEs	5.67	2.4	-58	.15

*Paired comparison between phase 1 and 2 made using t test including only the 6 units in both phases.

†Sum of nonintercepted potential ADEs and preventable ADEs.

[Bates et al, JAMA, 1998]

In three published studies on effect of CPOE on mortality in pediatric hospitals

A. No conclusion can be drawn regarding the effect of CPOE on mortality from these studies

B. CPOE was demonstrated to reduce mortality in all.

C. In some, but not all, CPOE caused increased mortality.

D. No studies of CPOE and mortality have been completed.

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D. No studies of CPOE and mortality have been completed.

ANSWER: A. These three studies were observational, and so causality can not be determined.

Mortality rates pediatric hospitals before and after CPOE

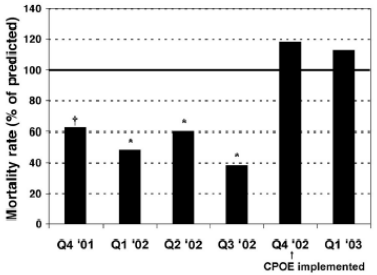


Fig 1. Observed mortality rates (presented as a normalized % of predicted mortality) during the 18-month study period are plotted according to quarter of year. Observed mortality rates were consistently better than predicted before CPOE implementation, but this relationship did not remain after CPOE implementation. *$P <$ .05 and †$P = .07$, (observed vs predicted mortality, z statistic). Q, quarter.

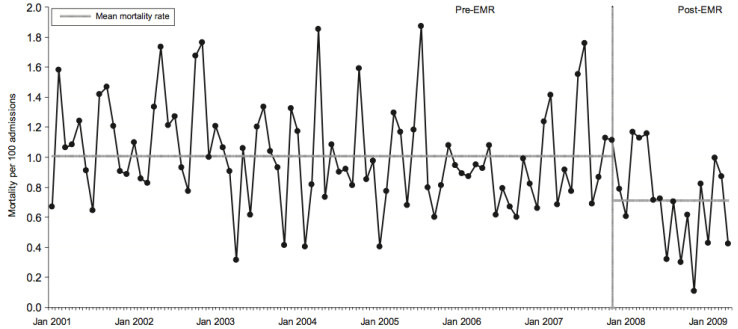


FIGURE 1
Hospital-wide mortality rate per 100 discharges according to month (excluding the obstetrical population). The pre-EMR period was between January 1, 2001, and October 31, 2007, and the postintervention period was between November 1, 2007, and April 30, 2009.

TABLE 2 Mortality Rates of PICU Patients Before or After CPOE Implementation

	Total Patients, *n*	Survivors, *n*	Nonsurvivors, *n*	Mortality, %	Relative Risk	95% CI	*P*
All patients	2533	2436	97	3.83	0.82	0.55–1.21	.32
Before CPOE	1232	1180	52	4.22			
After CPOE	1301	1256	45	3.46			
Transfers	284	262	22	7.75	0.66	0.29–1.47	.30
Before CPOE	125	113	12	9.60			
After CPOE	159	149	10	6.29			
Congenital cardiovascular disease	432	417	15	3.47	0.59	0.21–1.63	.30
Before CPOE	203	194	9	4.43			
After CPOE	229	223	6	2.62			

Protocol

is built of

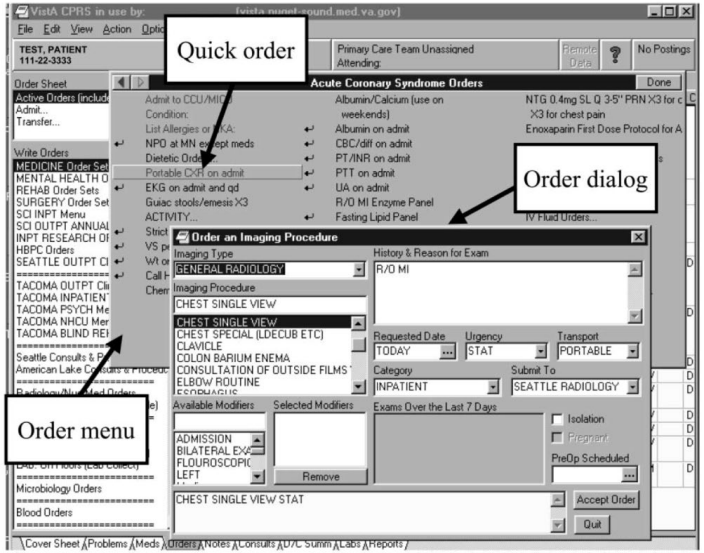
Order sets

is built of

Preconfigured orders

is built from

Order dialog



The Rationale for Order Sets

1. Reduce the time required to enter orders
2. Reduce errors and increase accuracy during order entry
3. Increase completeness of orders
4. “Built in” decision support and evidence driven care
5. Reduce variability in the care process and enhance compliance with “best practices”

[Payne 2003]

Slide courtesy of Matt Eisenberg, MD

CPOE effects on workflow

Beneficial	Detrimental
Order turn around time	Time spend entering orders
Remote access	In-person communication
Time for antibiotics to reach patient	Usability
Improved order legibility	Shifting responsibilities
Reduction in verbal orders	Communication of STAT orders
Ordering practitioner known	
Routing of results to Inbox	

[Niazkhani 2009]

Unintended consequences of CPOE

1. More/New Work Issues
2. Workflow Issues
3. Never Ending Demands
4. Paper Persistence
5. Communication Issues
6. Emotions
7. New Kinds of Errors
8. Changes in the Power Structure
9. Overdependence on Technology

[Ash JAMIA 2007]

Telemedicine
Revolutionized with Covid-19

Clinical use cases

- Primary and specialty care
- Teleconsultation
  - Psychiatry
  - Dermatology
  - Pathology
  - ENT
  - Retinography
- Teleradiology
- Telesurgery
- Remote retinal imaging
- Remote monitoring
- Remote ICU
- Remote procedures

Economic considerations

- Payer policies
- Bundled payment
- Policies during Public Health Emergency

Telehealth applications:

- **E-consult:** Asynchronous clinician-to-clinician communication based on record review (inpatient and outpatient)
- **Telephone visit:** Synchronous patient-clinician communication by phone
- **Remote patient monitoring (RPM):** the use of connected electronic tools to record personal health and medical data in one location for review by a provider in another location, usually at a different time.
- **Mobile health (mHealth):** health care and public health information provided through mobile devices. The information may include general educational information, targeted texts, and notifications about disease outbreaks

Healthit.gov

Telehealth applications, continued:

- **Live (synchronous) videoconferencing**: a two-way audiovisual link between a patient and a care provider
- **Store-and-forward (asynchronous) videoconferencing:** transmission of a recorded health history to a health practitioner, usually a specialist.
- **Patient-initiated messaging:** Synchronous chats with automated or live agents
- **Asynchronous patient portal messaging**

Telehealth federal policy changes during COVID-19

HIPAA flexibility for telehealth technology. Providers have more flexibility to use everyday technology for virtual visits during the COVID-19 public health emergency.

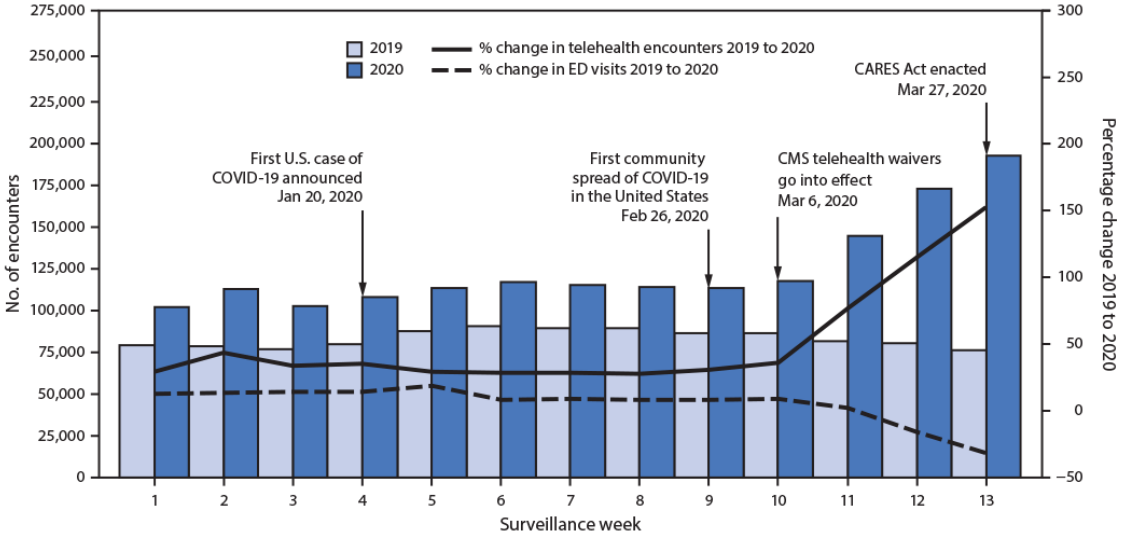
Medicare and Medicaid policies. Federal COVID-19 waivers and regulatory changes now make it easier for providers to deliver telehealth services to Medicare and Medicaid patients.

Telehealth licensing requirements and interstate compacts. Providers can deliver telehealth services across state lines, depending on rules set by state and federal policies.

Prescribing controlled substances. During the COVID-19 public health emergency, authorized providers can prescribe controlled substances via telehealth, without the need for an in-person medical evaluation.

Growth in telehealth during Covid-19

The 154% increase in telehealth visits during the last week of March 2020, compared with the same period in 2019



Telemedicine media & timing

Synchronous teleconferencing

- Dedicated hardware
- Broadly available tools
  - (e.g., Zoom)
  - Conferencing applications

Asynchronous telemedicine

- Store & forward
- Electronic mail
- Other

Additional suggested readings

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See also References in lecture pdf.

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