AMIA
INFORMATICS PROFESSIONALS. LEADING THE WAY.

1F – Evidence-based Practice

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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

K003. Core clinical informatics literature (e.g., foundational literature, principal journals, critical analysis of literature, use of evidence to inform practice)

2B – Evidence-Based Practice

Evidence-based medicine

Using EBM to answer questions about intervention (treatment)

- Diagnosis statistics covered in 2A-1 – Clinical Decision Making

Summarizing evidence

Clinical practice guidelines

Principal informatics journals

Evidence-based medicine (EBM)

A set of tools and disciplined approach to informing clinical decision-making

- Applies the best evidence available
- Most recent textbooks – manual (Guyatt, 2014); handbook (Guyatt, 2015); and update of "Sackett book" (Straus, 2018)

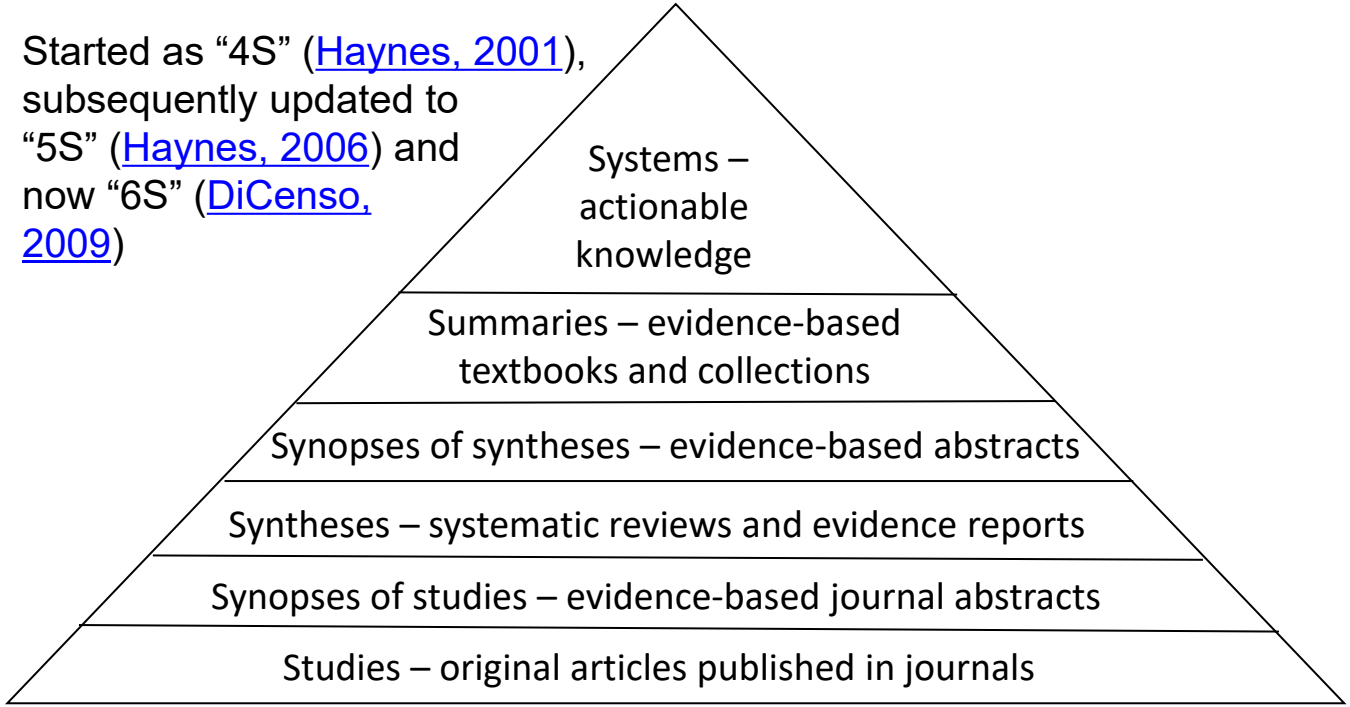
Allows clinical experience (art) to be integrated with best clinical science

Makes biomedical literature more clinically applicable and relevant

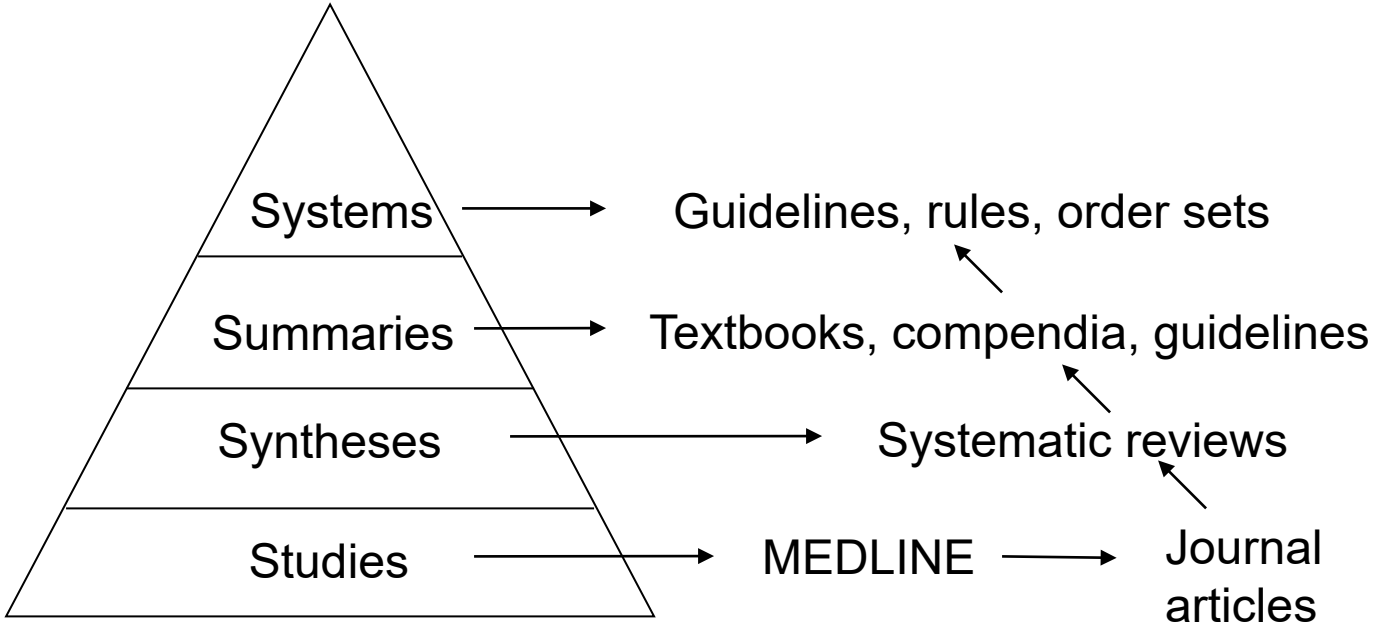
Cannot forget the caveat: "Absence of evidence is not evidence of absence" (Carl Sagan)

Hierarchy of evidence

Started as “4S” (Haynes, 2001), subsequently updated to “5S” (Haynes, 2006) and now “6S” (DiCenso, 2009)



Sources of evidence



Overview of the application of EBM

Steps include

- Phrasing a clinical question that is pertinent and answerable
- Identifying evidence to address the question
- Critically appraising the evidence to determine if it applies to the patient

Background vs. foreground questions

- Background questions ask for general knowledge about a disorder
  - Usually answered with textbooks and classical review articles
- Foreground questions ask for knowledge about managing patients with a disorder
  - Answered with EBM techniques

Foreground questions

Have three or four essential components (PICO)

- Patient and/or problem
- Intervention
- Comparison intervention (if appropriate)
- Outcomes

Example

- In an elderly patient with congestive heart failure, are beta blockers helpful in reducing morbidity and mortality without excess side effects?

Can also add timing and setting, i.e., PICOTS (Buckley, 2014)

Four categories of foreground questions

Intervention (or Treatment or Therapy) – benefit of treatment or prevention

Diagnosis – test diagnosing disease

Harm – etiology or cause of disease

Prognosis – outcome of disease course

Questions to ask about the results from any study

After retrieving one or more studies, ask for each

- Are the results valid?
- Are the results important?
- Can the results be applied to patient care?

Specific sub-questions for each depend on type of question and type of study

Using EBM to assess questions about interventions

Questions concerning benefit of a clinical intervention to treat or prevent disease

Can include drug therapy, diet therapy, surgery, alternative medicine, etc.

Best evidence comes from a randomized controlled trial (RCT) or meta-analysis of RCTs

- Patients similar in all regards with exception of intervention applied

Treatment effect

Usually measured in terms of risk of undesired outcomes, e.g., mortality, recurrence, complications, etc.

Relative measures – relative to control

- Relative risk (RR, risk ratio) – risk relative to control
  - Relative risk reduction
- Odds ratio (OR) – odds of having vs. not having event
- Hazard ratio (HR) – relative risk adjusted for time

Absolute measures – overall population

- Absolute risk reduction (ARR, risk difference) – absolute difference of risk
- Number needed to treat (NNT) – how many must be treated for one person to benefit

Measurement of treatment effect

Events / Intervention	Had event	No event	Total
Experimental	a	b	a+b
Control	c	d	c+d
Total	a+c	b+d	a+b+c+d

Events – e.g., death, complication, progression of disease, etc.
Assuming statistical significance:

- Experimental event rate (EER) = a / a+b (risk of event from experimental intervention)
- Control event rate (CER) = c / c+d (risk of event from control intervention)
- Relative risk (RR) or risk ratio = EER / CER
- Relative risk reduction (RRR) = 1 - RR
- Absolute risk reduction (ARR) or risk difference = CER - EER
- Number needed to treat (NNT) = 1 / ARR

Precision of estimate of treatment effect

True risk for population is unknown; need to assess with sample

Study result gives point estimate, but true result can vary due to chance (and bias if study not performed properly)

Assess possible range of results by calculating confidence interval (CI)

- Range of values that includes true value 95% of the time

Example: Use of dexamethasone in COVID-19

(RECOVERY Group, 2020)

Patients hospitalized for COVID-19

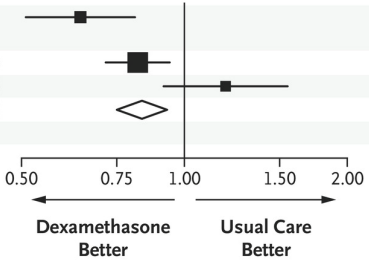
Randomly assigned to

- Receive oral or intravenous dexamethasone (at dose of 6 mg once daily) for up to 10 days
- Receive usual care alone

Primary outcome – mortality at 28 days

Respiratory Support at Randomization	Dexamethasone	Usual Care	Rate Ratio (95% CI)
	no. of events/total no. (%)		
Invasive mechanical ventilation	95/324 (29.3)	283/683 (41.4)	0.64 (0.51–0.81)
Oxygen only	298/1279 (23.3)	682/2604 (26.2)	0.82 (0.72–0.94)
No oxygen received	89/501 (17.8)	145/1034 (14.0)	1.19 (0.92–1.55)
All Patients	**482/2104 (22.9)**	**1110/4321 (25.7)**	**0.83 (0.75–0.93)**
			P<0.001

Chi-square trend across three categories: 11.6



Treatment effect – all patients

Events Intervention	Death	Survive	Total
Dexamethasone	482	1622	2104
Usual care	1110	3211	4321

- EER = 482 / 2104 = 0.229 (22.9%)
- CER = 1110 / 4321 = 0.257 (25.7%)
- RR = EER / CER = 0.892 (89.2%)
- RRR = 1 – RR = 0.108 (10.8%)
- ARR = CER – EER = 0.257 – 0.229 = 0.028 (2.8%)
- NNT = 1 / ARR = 36

Treatment effect – subgroup on mechanical ventilation

Events Intervention	Death	Survive	Total
Dexamethasone	95	229	324
Usual care	283	400	683

- EER = 95 / 324 = 0.293 (29.3%)
- CER = 283/683 = 0.414 (41.4%)
- RR = EER / CER = 0.708 (70.8%)
- RRR = 1 – RR = 0.292 (29.2%)
- ARR = CER – EER = 0.414 – 0.293 = 0.121 (12.1%)
- NNT = 1 / ARR = 8.25

Summarizing evidence

For many tests and treatments, there are multiple studies such that one study does not tell the whole story

As such, there are many “systematic reviews” or “evidence reports” that aim to bring all the evidence on a treatment or test together

Per 6S model, syntheses bring primary data together while summaries make it available to users in highly digested form

Results from a systematic review

May use meta-analysis, which combines results of multiple similar studies

Systematic review ≠ meta-analysis

- Studies may be too heterogeneous in terms of patient characteristics, settings, or other factors

When meta-analysis is done, summary measures employed usually include

- Odds ratio (OR) or relative risk/risk ratio (RR) for dichotomous variables (i.e., events)
- Mean difference (MD) or standardized mean difference (SMD) for continuous variables

One large producer of systematic reviews is Cochrane Collaboration

https://www.cochrane.org/

Most reviews include meta-analysis

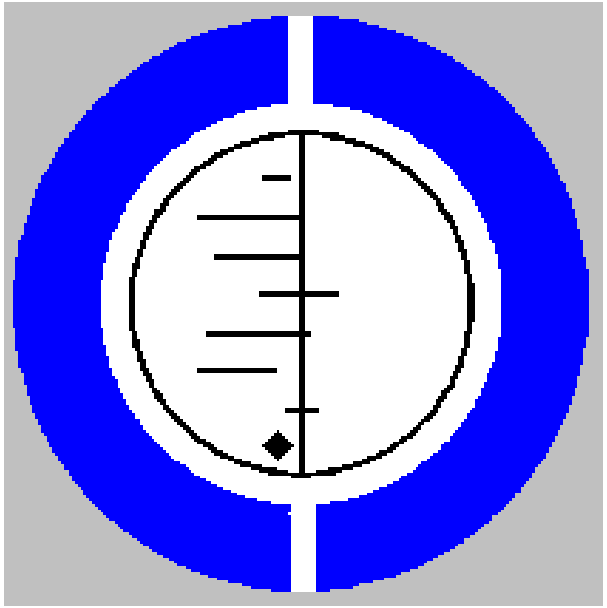
- Logo based on review of steroids in preterm labor

Each horizontal line represents a single RCT

- Span of line indicates CI

All study questions configured relative to vertical line

- Line represents OR=1 or MD/SMD=0
- Treatment benefit is to left of line
- CI not touching line indicates statistical significance



Clinical practice guidelines (CPGs)

CPGs are “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” (IOM, 2011)

- Usually aim to “normalize care”

May consist of

- Series of steps for providing clinical care
- Represented as text/tables or algorithms

Steps in construction include (Murad, 2017; Qaseem, 2019)

- Gathering evidence for important outcomes
- Grading quality of that evidence
- Ascertaining balance of benefits and harms
- Determining strength of recommendation
- Implementing and evaluating

Grading levels of evidence in studies: GRADE

Grading of Recommendations Assessment, Development, and Evaluation (GRADE) (Guyatt, 2011; Neumann, 2016)

https://www.gradeworkinggroup.org/

Study Design	Quality of Evidence	Lower if	Higher if
Randomized trial →	High	Risk of bias -1 Serious -2 Very serious	Large effect +1 Large +2 Very large
	Moderate	Inconsistency -1 Serious -2 Very serious	Dose response +1 Evidence of a gradient
Observational study →	Low	Indirectness -1 Serious -2 Very serious	All plausible confounding +1 Would reduce a demonstrated effect or
	Very low	Imprecision -1 Serious -2 Very serious	+1 Would suggest a spurious effect when results show no effect
		Publication bias -1 Likely -2 Very likely	

U.S. Preventive Services Task Force (USPSTF) recommendations

Recommendations based on grading evidence derived from a commissioned systematic review

- Grade A – certainty of evidence is high that the magnitude of net benefits is substantial
- Grade B – certainty of evidence is moderate that the magnitude of net benefits is either moderate or substantial, or that the certainty of evidence is high that the magnitude of net benefits is moderate
- Grade C – certainty of the evidence is either high or moderate that the magnitude of net benefits is small
- Grade D – certainty of the evidence is high or moderate that the magnitude of net benefits is either zero or negative
- Grade I – the evidence is insufficient to determine the relationship between benefits and harms (i.e., net benefit)

https://www.uspreventiveservicestaskforce.org/Page/Name/grade-definitions

Limitations of guidelines

May not apply in complex patients – for 15 common diseases, following best-known guidelines in elderly patients with comorbid diseases may have undesirable effects and implications for pay-for-performance schemes (Boyd, 2005)

May be incomplete or inaccurate – of 11 guidelines for oral medications in Type 2 diabetes, several varied from known best evidence, with those having evidence-based processes being judged of higher quality (Bennett, 2012)

Components may go out of date – study of ACC/AHA guidelines found rate of changes vary though lower for recommendations with evidence from multiple RCTs (Neuman, 2014)

Less than 25% of primary care CPGs rated as high quality (Molino, 2019)

- High-quality associated with higher number of authors, governmental institutions, and report of funding

Limitations of guidelines (cont.)

Evidence often does not exist

- For cardiology guidelines, level of evidence for recommendations (Fanaroff, 2019)
  - A [supported by data from multiple RCTs or a single, large RCT] – 8.5%
  - B [supported by data from observational studies or a single RCT] – 50.0%
  - C [supported by expert opinion only] – 41.5%
- Less than 10% of recommendations in American Thoracic Society CPGs supported by high-quality evidence, e.g., RCT or meta-analysis (Schumacher, 2019)

Where does one find CPGs?

Medical literature, i.e., PubMed/MEDLINE

ECRI Guidelines Trust – https://guidelines.ecri.org/

- Successor of National Guidelines Clearinghouse (NGC)

From many organizations

- Medical specialty societies, e.g.,
  - American College of Physicians - https://www.acponline.org/clinical-information/guidelines
  - American Heart Association/American College of Cardiology - https://professional.heart.org/professional/GuidelinesStatements/UCM_316885_Guidelines-Statements.jsp
- Government and related organizations, e.g.,
  - US Preventive Services Task Force - https://www.uspreventiveservicestaskforce.org/
- Healthcare delivery organizations and others

Key informatics journals

Journals of AMIA

- JAMIA – https://academic.oup.com/jamia
- JAMIA Open – https://academic.oup.com/jamiaopen

Methods of Information in Medicine (MIM)

International Journal of Medical Informatics (IJMI)

Journal of Medical Internet Research (JMIR)

JMIR Medical Informatics

Journal of Biomedical Informatics (JBI)

Applied Clinical Informatics (ACI)

- ACI Open

Bioinformatics

Journal of Digital Imaging (JDI)

Biomed Central (BMC, https://www.biomedcentral.com/)

- BMC Medical Informatics and Decision Making
- BMC Bioinformatics

Key Readings

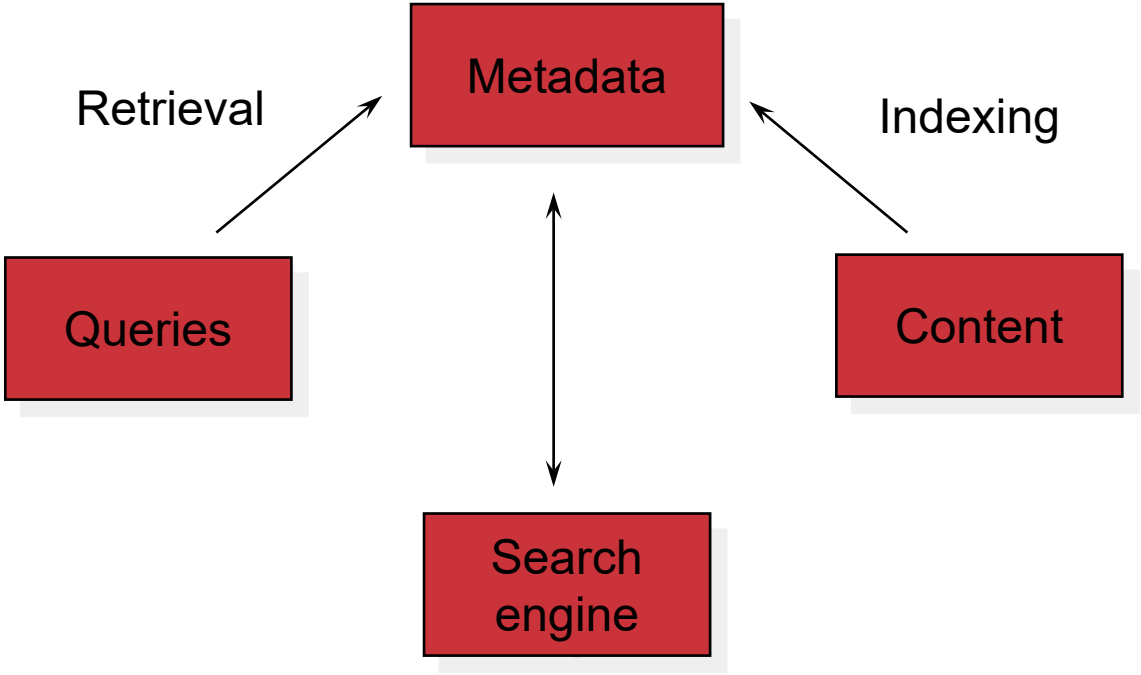
Straus, S.E., Glasziou, P., Richardson, W.S., Haynes, R.B., 2018. *Evidence-Based Medicine: How to Practice and Teach EBM, 5th edition*. ed. Elsevier.

Guyatt, G, Rennie, D, et al., Eds. (2015). *Users' Guides to the Medical Literature: Essentials of Evidence-Based Clinical Practice, Third Edition*. New York, NY, McGraw-Hill.

Hersh, W. (2020). *Information Retrieval: A Biomedical and Health Perspective (4th Edition)*. Springer.

Appendix

Basic concepts: information retrieval (IR) system (Hersh, 2020)



Intellectual tasks of IR

Indexing

- Assigning metadata to content items
- Can assign
  - Subjects (terms) – words, phrases from controlled vocabulary
  - Attributes – e.g., author, source, publication type

Retrieval

- Most common approaches use
  - Boolean – use of AND, OR, NOT
  - Natural language – words common to query and content

A classification of knowledge-based content

Bibliographic

- By definition rich in metadata

Full-text

- Everything on-line

Annotated

- Non-text annotated with text or structured text

Aggregations

- Bringing together all of the above

MEDLINE

References to biomedical journal literature

- Original medical IR application – launched in 1971, with literature dating back to 1966 (and now some older)
- Free to world since 1997 via PubMed – pubmed.gov

Produced by National Library of Medicine (NLM)

Statistics

- Over 24 million references to peer-reviewed literature
- Over 5,000 journals, mostly English language
- About 900,000 new references added yearly

Links to full text of articles and other resources

Annotated content

Non-text annotated with text or structured text, e.g.,

- Image collections, usually from “visual” specialties
- Citation databases, e.g., Science Citation Index
- Evidence-based medicine databases, e.g., JAMA Evidence
- Clinical decision support, from publishers or vendors
- Genomics databases, from NLM and others
- Other databases, e.g., ClinicalTrials.gov

Aggregations – integrating many resources

Clinical – major publishers now “bundle” their collections

Biomedical research – example is linked databases of NCBI

- https://www.ncbi.nlm.nih.gov/search/

Consumer – example is MEDLINEplus from NLM

- medlineplus.gov

Indexing

Assignment of metadata to content to facilitate retrieval

Two major types

- Human indexing with controlled vocabulary
  - Best known approach is MEDLINE applied by professional indexers using Medical Subject Headings (MeSH) vocabulary
- Automated indexing of all words

Medical Subject Headings (MeSH) vocabulary (Coletti, 2001)

Over 26,000 terms, with many synonyms for those terms

Hierarchical, based on 16 trees, e.g., Anatomy, Diseases, Chemicals and Drugs

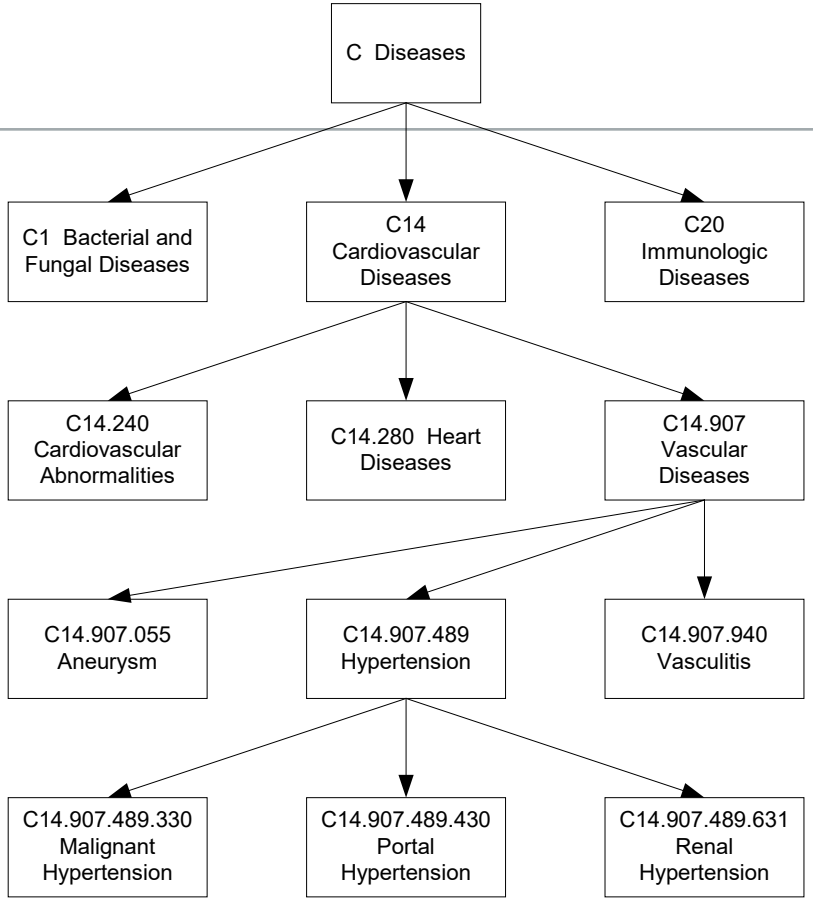
Contains 83 subheadings, which can be used to make a heading more specific, such as Diagnosis or Therapy

Also includes Publications Types, important for EBM, e.g., Randomized Controlled Trial, Systematic Review

MeSH browser allows exploration

- https://meshb.nlm.nih.gov/search

A slice of MeSH



Automated indexing

Indexing of all words that occur in content items

- In bibliographic databases, will usually include title, abstract, and sometimes other fields, e.g., author or subject heading
- In full-text documents, will usually include all text and title

Often use a stop word list to remove common words (e.g., the, and, which)

Some systems “stem” words to root form (e.g., coughs or coughing to cough)

Retrieval

Two general approaches

- Boolean, set-based, exact-match
- Natural language, automated, partial-match

They are not mutually exclusive, e.g., PubMed

Early systems tended to be Boolean

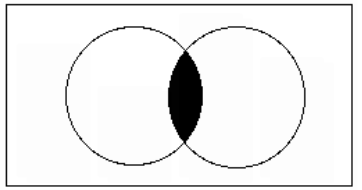
- Preferred by power users?

More recently have seen growth of natural language systems

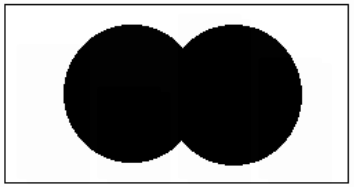
- Popular for Web searching

Boolean operators

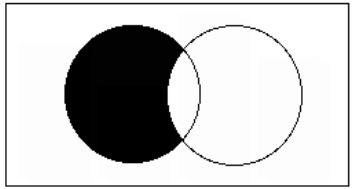
AND – only content items that have all terms



OR – content items that have any term



NOT – content items with one term but not other



PubMed – https://www.ncbi.nlm.nih.gov/pubmed/

NLM system for searching MEDLINE and related databases

- Includes some OLDMEDLINE (before 1966) as well as other records not indexed in MEDLINE

Based on Boolean heritage but has added a number of features of natural language searching over the years

- Search algorithm tries to map input to MeSH terms, author name, and other phrases
- Has traditional Boolean set capability in Advanced interface but essentially unnecessary now

Default output order is reverse chronological

Evaluation

Questions often asked (Hersh, 2020)

- Is system used?
- Are users satisfied?
- Do they find relevant information?
- Do they complete their desired task?

Most studied group is physicians, with systematic reviews of results (Hersh, 1998, Pluye, 2005)

Most IR evaluation research has focused on retrieval of relevant documents, which may not capture full spectrum of usage

Relevance-based measures

Most common approach to evaluation

- Recall (equivalent to sensitivity)

$$R = \frac{\#\,retrieved\ and\ relevant\ documents}{\#\,relevant\ documents\ in\ collection}$$

- Precision (equivalent to positive predictive value)

$$P = \frac{\#\,retrieved\ and\ relevant\ documents}{\#\,retrieved\ documents}$$

Example:

- 100 known relevant documents
- 50 documents retrieved
- 25 documents retrieved are relevant
- Recall = 25/100 = 25%
- Precision = 25/50 = 50%

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