HL7 Infobutton Standard

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Abstract

Computerized information retrieval tools are "infobuttons" that deliver contextually relevant knowledge resources into clinical information systems to support clinical decision-making (Braunstein, 2018). Providing a standard mechanism for clinical information systems to request context-specific clinical knowledge from online resources (Del Fiol et al., 2012) has become a widely adopted approach to help clinicians and patients answer their clinical questions in care. Based on the clinical context, which includes characteristics of the patient, provider, care setting, and clinical task (Greenes et al., 2018), infobuttons anticipate clinicians' and patients' questions and provide automated links to resources that may answer those questions. Although some communication behaviors may be more amenable to training, an infobutton displayed in the context of a patient's problem list, for example, may allow a clinician to retrieve treatment guidelines on a specific condition and increase patients' total level of active participation in healthcare interactions.

Keywords**:** Health Level Seven (HL7), Infobutton, Clinical Information Systems (CIS), Electronic Health Record (EHR), Clinical Decision Support (CDS), Standards Development Organizations (SDOs), Systematized Nomenclature of Medicine-Clinical Terms (SNOMEDCT), Digital Imaging Communication in Medicine (DICOM)

Introduction

The advent of the Meaningful Use legislation provided incentives to adopt qualifying Electronic Health Records (EHR), EHR Incentive Program, healthcare organizations, and healthcare providers are required to integrate Clinical Decision Support (CDS) into their federally certified EHR systems. Although alerts are one of the most common forms of CDS (Wong et al., 2018), it must be noted there are many interventions that make up the current CDS toolkit. In the book Improving Outcomes with Clinical Decision Support: An Implementer's Guide (Osheroff et al., 2012), the authors state that CDS interventions fall into four categories: Data Entry, Data Review, Assessment and Understanding, and Triggered by User Task. According to (Kaldjian, 2019; Van de Velde et al., 2018), the third category, Assessment, and Understanding, is concerned with satisfying the information needs of physicians and patients as they formulate, debate, and discuss treatment options and care plans. One innovative tool in this category is the Health Level Seven (HL7) Infobutton (Weir et al., 2021). An infobutton can be used in an electronic health record and appear next to a condition in a patient's problem list or medication in the medication list. The physician clicks on the button to learn more about the state and is immediately linked to an information source presenting detailed, evidence-based knowledge regarding the disease and its treatment. The same functionality applies to medications and their contraindications with other substances.

Background

Compromising the quality of care, clinicians and patients face numerous unmet needs in a collective knowledge base that highlights discrepancies between the current reality and the desired state (Pittman, 2019). Although online health knowledge resources capable of solving many of these knowledge needs are now widely available, fragmentation of health care and poor coordination of care hinder more effective and frequent use of these resources at the point of care (Balogh et al., 2015). According to Kola et al. (2009), infobutton is a point-of-care information retrieval application that automatically generates and sends queries to digital libraries using patient data extracted from electronic health records (EHR) and personal health records (PHR) systems to lower these barriers. Proposing a knowledge-based query expansion method that exploits the Unified Medical Language System (UMLS) to augment the proposed indexing and retrieval framework (Teixeira et al., 2017), the concept of an Infobutton Manager (IM) as a software component

1) supports the implementation of Infobuttons (Cimino et al., 2002)
2) facilitates integrating knowledge resources into EHR and PHR systems
3) The Clinical Decision Support Technical Committee was employed to develop the Context-aware knowledge retrieval (Infobutton) standard specification (Charalabidis et al., 2014).

"When the IM is called because a user has clicked on an infobutton icon in the Clinical Information System" (Greenes (Ed) 2011, p. 357), the IM receives a set of query parameters and then generates a HyperText Markup Language (HTML) for documents containing a set of processing tasks known as semantic parsing to convert clinical questions to logical forms (Roberts & Patra, 2017), each of which is a hyperlink following the syntax of the target content source that is used to run a query on heterogeneous data sources (Guilherme Del Fiol & Rocha,

n.d.). Intended to support context-specific access to online knowledge resources with EHR systems that offer URLs as the primary or exclusive communication protocol (Kubben et al., 2019), this implementation provides the context-aware knowledge retrieval Infobutton standard.

Currently, several content sources are available in the market, providing an Application Programming Interface (API) that allows Infobutton searches to be performed. Since every query is executed through their central API, application, and domain-specific functionality to include proprietary syntax and vocabularies can be provided by any software component to an infobutton (Kubben et al., 2019). With different levels of granularity according to the specific needs and requests, several Clinical Information Systems (CIS) that support the clinical diagnosis include Computerized Physician Order Entry (CPOE), Laboratory Information System (LIS), Pharmacy Information System (PIS), or Picture Archiving and Communication Systems (PACs) (Balgrosky et al., 2015) in the same institution may implement calls to an IM. Since many of these applications are provided by vendors (Del Fiol et al., 2012), additional software would be necessary for each IM the vendor would like to link. According to Papazoglou & van den Heuvel (2007), the goal is to enable a stepwise transition from URL-based performances to a services-oriented approach.

Description of How the CDS Rules Will Be Utilized

Public health laboratories run by state and local health departments to diagnose diseases and protect the public from health threats (Inhorn et al., 2010) often receive isolates submitted for reference testing. As we learn to take a more active role in our medical care, where is the test performed? Can a developer or validation engineer comprehend outside the environment and explore the characteristics of the software, raising discoveries that will then be classified as reasonable behavior or failures? Just as tests vary, labs also vary in complexity, the volume of tests performed, the ability to the qualitative or quantitative determination of an increasing range of analytes, and the number and type of professionals who serve the testing (Xenitidou & Edmonds, 2014), the information about the original clinical sample the isolate also needs to be conveyed. To ensure that the tested specimens reflect the best choices from the available examples (Greytak et al., 2018), testing nucleic acid extracted from genetic changes in normal tissue cells that convert them to cancer cells will resolve the clinical question. Following the collection, preparation, and transport, where would the following attributes of that original specimen be conveyed? Not all of these would be required every time (Greytak et al., 2018):

- Specimen type (at minimum)
- Source site
- Collection method (if necessary)
- Additives/transport media (if required)

Justification For Creation

Several domains in HL7 use specimens in their ability to perform laboratory tests to accept, modify, or reject an order with differing use case requirements (Iglesias, 2020). There is a need for flexible standards, guidelines, and methodologies by which various healthcare systems can communicate and extend on specific projects and in particular domains. According to Bos &

the International Council on Medical and Care Compunetics (2010), as long as they support workflow in their respective environment, the object-oriented technology for database and software systems Domain Analysis Model (DAM) intends to represent all data elements, regardless of use in data exchange. The input was provided from Orders and Observations, Clinical Genomics, Interventional Imaging, and Anatomic Pathology (Balogh et al., 2015).

Actions To Take To Implement The CDS Rule

1. The clinical sample is submitted to the testing laboratory
2. The testing laboratory provides testing on the clinical model, and in the process, it creates a derived specimen
3. A testing laboratory cannot complete testing on the derived specimen
4. The derived specimen is forwarded to the reference laboratory for further testing
5. The reference laboratory receives the derived sample and all information required to interpret the requested test correctly
6. The reference laboratory completes testing and provides the result to the testing laboratory, which forwards it to the original ordering provider (HL7 International, 2017)

Identify Necessary Team Members And Their Roles

1. Testing Laboratory
    - The testing laboratory reports the results of its testing along with the results from the reference lab is only acceptable if it's accompanied by an authenticated medical record supporting the physician's intent to order the tests (Wians, 2009)
2. Reference Laboratory
    - The reference library completes the review for continuous consolidation testing derived from the specimen

- Monitoring to achieve quality and accurate test results is sent to the testing laboratory

Steps Needed To Obtain Stakeholder Approval

PA-C Perrin D. Reyea sees patient Robert Taylor Martin, Jr., a 49-year-old African-American male of Nigerian Ancestry, for Diverticulitis, abdominal pain, and screening for colon cancer who schedules a Colonoscopy and upper Endoscopy and their ambulatory surgery center, Hacienda Surgery Center. During the exam, Hacienda Surgery Center isolates colon polyps or bowel cancer to help diagnose unexplained Diverticulitis and abdominal pain and sends the isolate to the state Public Health Laboratory, where it is identified as *Mycobacterium avium* subspecies *paratuberculosis* (MAP), the cause of chronic intestinal disease in domestic and wild ruminants, is one suspected cause of Idiopathic Inflammatory Bowel Disease (IIBD) (Pierce, 2018). The state Public Health Laboratory cannot further subtyping and forward the isolate to the Centers for Disease Control. The American Joint Committee on Cancer called the TNM staging system for identification and subtyping (Carter, 2021; Hermanek et al., 2012) essential to determine the best treatment approach.

According to Kubben et al. (2019), the notion that machine learning and its algorithmic paradigms to evaluate an artifact successfully should be efficiently computable. Determining the usability of an artifact that allows a single access point and unified access to models and artifacts for querying is equivalent to query containment from database theory (France et al., 2012). This problem is known to be undecidable for arbitrary queries of relational algebra. Still, it is also decidable and equivalent to query evaluation for the restricted class of conjunctive queries. Represented with a vocabulary consisting of codes that determine the specific statement expressed in the health quality domain, this problem is further complicated by terminology mapping (Saitwal, 2012). As identified by the vocabularies involved (Matthijs,

2016), the meaning of each clinical statement must be preserved for the health-quality artifacts to operate correctly. With the implication often represented in different nomenclatures in different systems to include differing schemas across various patient data sources, a mapping between the languages is required to facilitate the expression and evaluation of the artifact. According to Marco-Ruiz et al. (2016), the solution to this problem is to create a well-defined interface between the clinical data provided by patient data sources and the usage of that data within any given artifact.

First, all clinical data within a knowledge artifact must be represented with a standard data model as long as the model represents the information that must be reasoned about (Marco-Ruiz et al., 2016). By separating the knowledge artifacts from the software and providing access through linkage services, clinical programs can keep pace with the rapidly changing and expanding medical environment. Second, all references to clinical data within a health quality artifact are represented using a specific type of expression "are required beyond FHIR to use artifacts within a CDS system" (Ohno-Machado & Séroussi, 2019, p. 1693). The purpose of this restriction is two-fold allows the necessary data for evaluation to be determined solely by inspection of the artifact and for simple and reliable implementation of the interface between the evaluation engine and the clinical data source because the criteria used to request information are well-defined and straightforward. Third, using standard terminologies within the actual data, the language can guarantee that any given clinical statement referenced in an artifact "can be used at the analysis level and mapped to HL7& RIM-based artifacts a subsidiary step" (Benson & Grieve, 2020, p. 341). Other than stating that there is an expectation that standard terminologies will be used to ensure semantic consistency between the clinical data source and the reasoning expressed in the artifacts, this is the terminology problem.

Conclusion

Lab tests, radiology, and pharmacy are areas where both messaging and the EHR play a role in communication. As stated above, messaging is necessary for these areas when placing orders and receiving results. Still, the results could be communicated to another standards-based EHR system more quickly and efficiently using EHR extracts rather than messages. There is much need for international EHR content standards required in security, terminology, and demographics to support integrated medical software systems with embedded transcription functionality. Recognizing standards used in Health IT, such as SNOMED-CT, IHE, and GS1, terminology, according to Benson & Grieve (2020), is perhaps the most high-risk area of EHR interoperability. Produced by health informatics, Standardisation Developing Organizations (SDOs), rather than reducing ambiguity in communication so that actions taken are consistent with the actual meaning of the data, health terminologies that have been developed from an original core reveal the consequences of limited literacy on health and healthcare (Tabakov et al., 2020). In addition to core atomic terms, which suggest that the accounting functions of EMR are impinging on the ability of medical personnel to coordinate work (Pine & Mazmanian, 2014), several open specifications for health service interfaces have been developed. Although some need revision and incorporation into architectures for netcentric computing systems (Bondavalli et al., 2016), messaging standards to include Health Level Seven (HL7), Digital Imaging Communication in Medicine (DICOM), and other standards-based transactions such as the College of American Pathologists (CAP) Systematized Nomenclature of Medicine – Clinical Terms (SNOMED-CT), Institute of Electrical and Electronics Engineers (IEEE), National Council on Prescription Drug Programs (NCPDP), and Laboratory Logical Observational Identifier Name Codes (LOINCs) (Wager & Glaser, 2017) play a crucial role for interoperability between ancillary systems; lab, pharmacy, cardiology, radiology, and other designs that typically

sit apart from the core clinical functions of an electronic health record. Even those EHR systems built on the same platform, in either implementation or restriction, or between two non-standardized EHR systems are necessarily interoperable because they are often highly customized to an organization's unique workflow and preferences. Because qualitative, quantitative, and mixed methods can be applied in the implementation and can involve multiple health care professionals across disciplinary boundaries, the "components to support the ubiquitous exchange, sharing and liquidity of operational, clinical data stored in electronic health records" according to (Rea et al., 2012) is critical. To achieve this information flow, improved interoperability across health care organizations, laboratory, and radiology information systems. Therefore, messaging standards will always be necessary for lab, imaging, and pharmacy orders and results since labs and similar systems do not conform to the survey definition.

Annotated Reference

Balogh, E., Miller, B. T., Ball, J., & Institute of Medicine (U.S.). (2015). *Improving diagnosis in health care*.

Improving Diagnosis in Health Care, a continuation of the landmark Institute of Medicine reports *To Err Is Human* (2000) and *Crossing the Quality Chasm* (2001), finds that diagnosis and, in particular, the occurrence of diagnostic errors–has been largely unappreciated in efforts to improve the quality and safety of health care.

Balgrosky, J. A., Brady, J. W., & Speaker, R. (2015). *Essentials of health information systems and technology*.

This book will provide undergraduate and early graduate students with a solid understanding not only of what is needed for a successful healthcare career in HIS but also of the vast frontier that lies before us as we develop new tools to support improved methods of care, analytics, policy, research, and public health

Benson, T., & Grieve, G. (2020). *Principles of health interoperability: FHIR, HL7, and SNOMED CT*. Cham: Springer.

The book is organized into four parts. The first part covers health interoperability principles, why it matters hard, and why models are essential to the solution. The second part covers clinical terminology and SNOMED CT. The third part covers the primary HL7 standards: v2, v3, CDA, and IHE XDS. The new fourth part covers FHIR and has been contributed by Grahame Grieve, the original FHIR chief.

Bondavalli, A., Bouchenak, S., & Kopetz, H. (Eds.). (2016). *Cyber-physical systems of systems: foundations–a conceptual model and some derivations: the AMADEOS legacy* (Vol. 10099). Springer.

This book's objective is to present the foundational concepts and their relationships in a single consistent body. These form a conceptual basis for the description and Understanding of SoSs and go deeper into what we consider the characterizing and distinguishing elements of SoSs: time, emergence, evolution, and dynamicity

Bos, L., & International Council on Medical and Care Compunetics. (2010). *Medical and care compunetics 6*. Amsterdam: IOS Press.

This book presents proceedings from the International Council on Medical and Care Compunetics (ICMCC), focusing on knowledge exchange on this subject.

Braunstein, M. L. (2018). Pre-FHIR Interoperability and Clinical Decision Support Standards. In Health Informatics on FHIR: How HL7's New API is Transforming Healthcare (pp. 151-177). Springer, Cham

This book goes on to discuss health informatics from a historical perspective, its current state, and its likely future state now that electronic health record systems are widely deployed, the HL7 Fast Healthcare Interoperability standard is being rapidly accepted as the means to access the data stored in those systems and analytics is increasingly being used to gain new knowledge from that aggregated clinical data.

Carter, B. W. (2021). *Imaging of the mediastinum*.

Articles will include ITMIG Definition of Mediastinal Compartments; Imaging of the Anterior/Prevascular Mediastinum; Thymic Epithelial Neoplasms: Radiologic-Pathologic Correlation; Thymic Epithelial Neoplasms: TNM Staging; Added Value of MR Imaging in the Evaluation of Mediastinal Lesions; Imaging of the Middle/Visceral Mediastinum; Esophageal Cancer: Radiologic-Pathologic Correlation; Esophageal Cancer: TNM Staging; Cardiac Neoplasms: Radiologic-Pathologic Correlation; Potential Pitfalls in

Imaging of the Mediastinum; Imaging-guided Biopsies and Interventions of Mediastinal Lesions; Imaging of the Posterior/Paravertebral Mediastinum; and more!

Charalabidis, Y., Lampathaki, F., & Jardim-Gonçalves, R. (2014). *Revolutionizing enterprise interoperability through scientific foundations*.

Revolutionizing Enterprise Interoperability through Scientific Foundations offers information on the latest advancements and research for Enterprise Interoperability knowledge and core concepts, theories, and future directions. This book is an essential resource for researchers and practitioners in the Enterprise Interoperability field and related areas.

Cimino, J. J., Li, J., Bakken, S., & Patel, V. L. (2002). Theoretical, empirical and practical approaches to resolving the unmet information needs of clinical information system users. In *Proceedings of the AMIA Symposium* (p. 170). American Medical Informatics Association.

Hypothesize that when clinicians review clinical data in an electronic medical record, the information needs that arise are predictable, based on several situational factors. This paper describes how the theory, observations, and practical solutions can come together to improve clinician decision-making by resolving information needs.

Del Fiol, G., Huser, V., Strasberg, H. R., Maviglia, S. M., Curtis, C., & Cimino, J. J. (2012). Implementations of the HL7 Context-Aware Knowledge Retrieval ("Infobutton") Standard: challenges, strengths, limitations, and uptake. Journal of biomedical informatics, 45(4), 726-735. http://dx.doi.org/10.1016/j.jbi.2011.12.006

Computerized information retrieval tools are known as "infobuttons" that deliver contextually relevant knowledge resources into clinical information systems to support clinical decision-making. The Health Level Seven International(HL7)Context-Aware

Knowledge Retrieval (Infobutton) Standard specifies a standard mechanism to enable infobuttons on a large scale.

France, R. B., Kazmeier, J., Breu, R., & Atkinson, C. (Eds.). (2012). *Model Driven Engineering Languages and Systems: 15th International Conference, MODELS 2012, Innsbruck, Austria, September 30--October 5, 2012, Proceedings* (Vol. 7590). Springer.

The 50 papers presented in this volume were carefully reviewed and selected from a total of 181 submissions. They are organized in topical sections named: metamodels and domain-specific modeling; models at runtime; model management; modeling methods and tools, consistency analysis, software product lines; foundations of modeling; static analysis techniques; model testing and simulation; model transformation; model matching, tracing and synchronization; modeling practices and experience; and model analysis.

Greenes, R. A., Bates, D. W., Kawamoto, K., Middleton, B., Osheroff, J., & Shahar, Y. (2018). Clinical decision support models and frameworks: seeking to address research issues underlying implementation successes and failures. Journal of biomedical informatics, 78, 134-143

Many approaches have been proposed and evaluated to address limitations, drawing on theoretical frameworks and management, technical and other disciplines, and experiences. Because of the multiple perspectives involved, it seems clear that no single model or framework is adequate to encompass these challenges. This Viewpoint paper seeks to review the various foci of CDS and to identify aspects in which theoretical models and frameworks for CDS have been explored or could be explored and where they might be expected to be most helpful.

Greytak, S. R., Engel, K. B., Zmuda, E., Casas-Silva, E., Guan, P., Hoadley, K. A., ... & Moore, H. M. (2018). National Cancer Institute biospecimen evidence-based practices: harmonizing procedures for nucleic acid extraction from formalin-fixed, paraffin-embedded tissue. *Biopreservation and biobanking*, *16*(4), 247-250. https://doi.org/10.1089/bio.2018.0046

BBRB has developed a document series termed Biospecimen Evidence-Based Practices (BEBP) to facilitate implementing evidence-based practices in biospecimen handling, which contains step-by-step procedural guidelines derived from peer-reviewed primary research articles and expert experience. The BEBP series aims to promote a practical level of standardization and improve overall biospecimen quality and data reproducibility by specifying both optimal methods and suitable alternatives while merging published evidence with the practical knowledge of experts in the field.

Guilherme Del Fiol, M. D., & Rocha, R. HL7 Infobutton API Proposal.

Infobutton is a point-of-care information retrieval application that automatically generates and sends queries to digital libraries using patient data extracted from the electronic medical record. Cimino proposed the concept of an Infobutton Manager as a software component that supports the implementation of Infobuttons in an institution and application-independent fashion

Hermanek, P., & Sobin, L. H. (Eds.). (2012). *TNM classification of malignant tumours*. Springer Science & Business Media.

Although the classification has found wide acceptance, some workers have pointed out that individual definitions and rules for staging are not sufficiently detailed. This can lead to inconsistent application of the classification, the antithesis of standardization.

HL7 International. (2017). *HL7 Version 3 Domain Analysis Model: Specimen, Release 2*. HL7.org. Retrieved June 5, 2021, from http://www.hl7.org/documentcenter/public/wg/orders/V3_DAM_Specimen_R2_INFORM_2017JAN_20170322.docx

Founded in 1987, Health Level Seven International (HL7) are a not-for-profit, ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery, and evaluation of health services. More than 1,600 members support HL7 from over 50 countries, including 500+ corporate members representing healthcare providers, government stakeholders, payers, pharmaceutical companies, vendors/suppliers, and consulting firms

Iglesias, N., Juarez, J. M., & Campos, M. (2020). Comprehensive analysis of rule formalisms to represent clinical guidelines: Selection criteria and case study on antibiotic clinical guidelines. *Artificial intelligence in medicine*, *103*, 101741. https://doi.org/10.1016/j.artmed.2019.101741

The overuse of antibiotics in clinical domains is causing an alarming increase in bacterial resistance, thus endangering their effectiveness in treating highly recurring severe infectious diseases. While Clinical Guidelines (*CGs*) focus on the correct prescription of antibiotics in a narrative form, *Clinical Decision Support Systems* (*CDSS*) operationalize the knowledge in *CGs* in the form of rules at the point of care.

Inhorn, S. L., Astles, J. R., Gradus, S., Malmberg, V., Snippes, P. M., Wilcke, B. W., Jr, & White, V. A. (2010). The State Public Health Laboratory System. *Public health reports*

(Washington, D.C. : 1974), 125 Suppl 2(Suppl 2), 4–17. https://doi.org/10.1177/00333549101250S202

To enhance the realization of the NLS, the Association of Public Health Laboratories (APHL) launched a 2004 State Public Health Laboratory System Improvement Program. In the same year, APHL developed a Comprehensive Laboratory Services Survey to measure improvement through the decade to ensure that essential PHL services are provided.

Kaldjian, L. C. (2019). Understanding Conscience as Integrity: Why Some Physicians Will Not Refer Patients for Ethically Controversial Practices. *Perspectives in biology and medicine*, *62*(3), 383-400.

The act of referral is the focal point of this essay because it appears to be at the front line of some current debates and legal contests about the extent to which society is willing to accommodate conscientious practice by physicians. Some see referrals as a way to balance respect for physician integrity by promoting patient autonomy; others see referrals as a mistaken attempt at compromise that misunderstands the meaning of moral responsibility and participation. Understanding conscience as integrity helps explain the moral seriousness of conscientious practice and reinforces the need for professional and legal accommodations that respect it.

Kola, J., Wong, W. K., & Buddala, B. (2019). Making clinical trials available at the point of care-connecting Clinical trials to Electronic Health Records using SNOMED CT and HL7 InfoButton standards.

This paper describes experiences of using SNOMED CT and HL7 InfoButton standards to make clinical trials from a trial registry accessible to clinicians within an Electronic Health Record (EHR) system in University College Hospitals, London. In particular, the

use of HL7 InfoButton standard [15] as a standardized interface for a clinical trials repository, which we believe is a first of its kind in the UK.

Kubben, P., Dumontier, M., & Dekker, A. L. A. J. (2019). *Fundamentals of clinical data science*.

This open-access book comprehensively covers the fundamentals of clinical data science, focusing on data collection, modeling, and clinical applications. Topics covered in the first section on data collection include: data sources, data at scale (big data), data stewardship (FAIR data), and related privacy concerns.

Matthijs, G., Souche, E., Alders, M., Corveleyn, A., Eck, S., Feenstra, I., ... & Bauer, P. (2016). Guidelines for diagnostic next-generation sequencing. *European Journal of Human Genetics*, *24*(1), 2-5.

On behalf of EuroGentest and the European Society of Human Genetics, guidelines for evaluating and validating next-generation sequencing (NGS) applications for diagnosing genetic disorders are presented. The work was performed by a group of laboratory geneticists and bioinformaticians and discussed with clinical geneticists, industry and patients' representatives, and other stakeholders in the field of human genetics. The statements that were written during the elaboration of the guidelines are presented here

Marco-Ruiz, L., Pedrinaci, C., Maldonado, J. A., Panziera, L., Chen, R., & Bellika, J. G. (2016). Publication, discovery, and interoperability of clinical decision support systems: a linked data approach. *Journal of biomedical informatics*, *62*, 243-264.

The high costs involved in developing Clinical Decision Support Systems (CDSS) make it necessary to share their functionality across different systems and organizations. Service-Oriented Architectures (SOA) have been proposed to reuse CDSS by

encapsulating them in a Web service. However, substantial barriers to sharing CDS functionality remain due to the lack of expressiveness of services' interfaces.

Ohno-Machado, L., & Séroussi, B. (2019). *MEDINFO 2019: Proceedings of the 17th World Congress on Medical and Health Informatics*. Amsterdam: IOS Press, Incorporated.

Combining and integrating cross-institutional data remains challenging for both researchers and those involved in patient care. Patient-generated data can contribute precious information to healthcare professionals by enabling monitoring under everyday life conditions and helping patients play a more active role in their care. This book presents MEDINFO 2019, the 17th World Congress on Medical and Health Informatics, held in Lyon, France, from 25 to 30 August 2019.

Osheroff, J. A., Teich, J. M., Levick, D., Saldana, L., Velasco, F. T., Sittig, D. F., ... & Jenders, R. A. (2012). *Improving outcomes with clinical decision support: an implementer's guide*. Himss Publishing.

Co-published by HIMSS, the Scottsdale Institute, AMIA, AMDIS, and SHM, this second edition of the authoritative guide to CDS implementation has been substantially enhanced with expanded and updated guidance on using CDS interventions to improve care delivery and outcomes. This edition has been reorganized into parts that help readers set up (or refine) a successful CDS program in a hospital, health system, or physician practice; and configure and launch specific CDS interventions.

Papazoglou, M. P., & Van Den Heuvel, W. J. (2007). Service oriented architectures: approaches, technologies and research issues. *The VLDB Journal*, *16*(3), 389-415.

This paper reviews technologies and approaches that unify the principles and concepts of SOA with those of event-based programming. The paper also focuses on the ESB and

describes a range of functions designed to offer a manageable, standards-based SOA backbone that extends middleware functionality by connecting heterogeneous components and systems and offering integration services.

Pierce, E. S. (2018). Could Mycobacterium avium subspecies paratuberculosis cause Crohn's disease, ulcerative colitis… and colorectal cancer?. *Infectious agents and cancer*, *13*(1), 1-6. https://doi.org/10.1186/s13027-017-0172

Infectious agents have known causes of human cancers. Schistosoma japonicum and Schistosoma mansoni cause a percentage of colorectal cancers in countries where the respective Schistosoma species are prevalent. Colorectal cancer is a complication of ulcerative colitis and colonic Crohn's disease, the two primary forms of idiopathic inflammatory bowel disease (IIBD). Mycobacterium avium subspecies paratuberculosis (MAP), the cause of chronic intestinal disease in domestic and wild ruminants, is one suspected cause of IIBD. MAP may therefore be involved in the pathogenesis of IIBD-associated colorectal cancer and colorectal cancer in individuals without IIBD (sporadic colorectal cancer) in countries where MAP infection of domestic livestock is prevalent, and MAP's presence in soil and water is extensive.

Pine, K. H., & Mazmanian, M. (2014, February). Institutional logics of the EMR and the problem of'perfect'but inaccurate accounts. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 283-294). https://doi.org/10.1145/2531602.2531652

This paper uses grounded empirical data to explore how this promise plays out in the everyday tasks of healthcare providers. Building on the small body of CSCW literature that suggests that the accounting functions of EMR are impinging on the ability of medical personnel to coordinate work, we draw on the theoretical lens of new

institutionalism to outline how specific institutional logic around safety and accountability are shaping the experience of EMR systems in situ.

Pittman, P. (2019). Activating nursing to address unmet needs in the 21st century.

This report argues that the nursing profession could contribute significantly to addressing this crisis if it embraces its historical role at the intersection of medicine and society and if educators, employers, and policymakers work with nurses to create jobs with functions that allow them to utilize their education and training more effectively

Rea, S., Pathak, J., Savova, G., Oniki, T. A., Westberg, L., Beebe, C. E., ... & Chute, C. G. (2012). Building a robust, scalable and standards-driven infrastructure for secondary use of EHR data: the SHARPn project. *Journal of biomedical informatics, 45*(4), 763-771. https://doi.org/10.1016/j.jbi.2012.01.009

In this paper, we present an overview of the architecture of this prototype SHARPn platform, describe the data flow from EHR to standardized data inputs for phenotyping, and discuss the challenges for shared, standardized secondary EHR data usage as observed in this data throughput demonstration.

Roberts, K., & Patra, B. G. (2017). A semantic parsing method for mapping clinical questions to logical forms. In *AMIA Annual Symposium Proceedings* (Vol. 2017, p. 1478). American Medical Informatics Association.

This paper presents a method for converting natural language questions about structured data in the electronic health record (EHR) into logical forms. The analytic documents can then subsequently be converted to EHR-dependent structured queries. The natural language processing task, known as semantic parsing, has the potential to transform questions into logical forms with extremely high precision, resulting in a system that is usable and trusted by clinicians for real-time use in clinical settings.

Saitwal, H., Qing, D., Jones, S., Bernstam, E. V., Chute, C. G., & Johnson, T. R. (2012). Cross-terminology mapping challenges: a demonstration using medication terminological systems. *Journal of biomedical informatics*, *45*(4), 613-625.

This paper demonstrates the complexity and challenges of mapping across terminological systems in the context of medication information. It provides a review of terminological medication systems and their linkages, then describes a case study in which we mapped proprietary medication codes from an electronic health record to SNOMED CT and the UMLS Metathesaurus

Tabakov, S., Milano, F., & Sprawls, P. (Eds.). (2020). *Encyclopaedia of medical physics*. Taylor & Francis.

Co-published by the European Medical Imaging Technology e-Encyclopaedia for Lifelong Learning (EMITEL) consortium and supported by the International Organization for Medical Physics (IOMP), the Encyclopaedia of Medical Physics contains nearly 2,800 cross-referenced entries relating to medical physics and associated technologies.

Teixeira, M., Cook, D. A., Heale, B. S., & Del Fiol, G. (2017). Optimization of infobutton design and Implementation: A systematic review. *Journal of biomedical informatics*, *74*, 10-19.

Infobuttons are clinical decision tools embedded in the electronic health record that attempt to link clinical data with context-sensitive knowledge resources. The author systematically reviewed technical approaches contributing to improved infobutton design, implementation, and functionality.

Van de Velde, S., Heselmans, A., Delvaux, N., Brandt, L., Marco-Ruiz, L., Spitaels, D., ... & Flottorp, S. (2018). A systematic review of trials evaluating success factors of

interventions with computerized clinical decision support. *Implementation Science*, *13*(1), 1-11.

Computerized clinical decision support (CDS) can potentially better inform decisions, and it can help with the management of information overload. It is perceived to be a vital component of a learning health care system. Despite its increasing implementation worldwide, it remains uncertain why the effect of CDS varies and which factors make CDS more effective.

Wager, K. A., Lee, F. W., & Glaser, J. P. (2017). *Health care information systems: A practical approach for health care management*

Health Care Information Systems is the newest version of the acclaimed text that offers the fundamental knowledge and tools needed to manage information and information resources effectively within various health care organizations. It reviews the major environmental forces that shape the national health information landscape and offers guidance on implementing, evaluating, and managing health care information systems. It also reviews relevant laws, regulations, and standards and explores the most pressing issues pertinent to senior-level managers

Wians, F. H. (2009). Clinical laboratory tests: which, why, and what do the results mean?. *Laboratory Medicine*, *40*(2), 105-113. doi.org/10.1309/LM4O4L0HHUTWWUDD

This CE Update discusses the laboratory testing cycle and its importance in diagnostic decision-making. This discussion will begin with general comments about ordering clinical laboratory tests, followed by "real-world" examples to illustrate these approaches.

Weir, C. R., Taber, P., Taft, T., Reese, T. J., Jones, B., & Del Fiol, G. (2021). Feeling and thinking: can theories of human motivation explain how EHR design impacts clinician burnout?. *Journal of the American Medical Informatics Association*, *28*(5), 1042-1046.

This piece examines existing research on the importance of 3 psychological drives concerning healthcare technology: goal-based decision-making, sense-making, and agency/autonomy. Because these motives are ubiquitous, foundational to human functioning, automatic, and unconscious, they may be overlooked in technological interventions.

Wong, A., Amato, M. G., Seger, D. L., Rehr, C., Wright, A., Slight, S. P., ... & Bates, D. W. (2018). Prospective evaluation of medication-related clinical decision support over-rides in the intensive care unit. *BMJ quality & safety*, *27*(9), 718-724.

Clinical decision support (CDS) displayed in electronic health records has reduced the incidence of medication errors and adverse drug events (ADE). Recent data suggested that medication-related CDS alerts were frequently overridden, often inappropriately. Patients in the intensive care unit (ICU) are at an increased risk of ADEs; however, limited data exist on the benefits of CDS in the ICU. This study evaluates potential harm associated with medication-related CDS overriding in the ICU.

Xenitidou, M., & Edmonds, B. (2014). *The complexity of social norms*.

This book explores that normative behavior is part of a complex of social mechanisms, processes, and constantly shifting narratives. From this perspective, norms are not a kind of self-contained social object or fact, but rather an interplay of many things that we label as norms when we 'take a snapshot' of them at a particular instant. Further, this book pursues the hypothesis that considering the dynamic aspects of these phenomena sheds new light on them.