The Impact of Domain Knowledge on Structured Data Collection and Templated Note Design

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Information seeking behavior, medical informatics, knowledge management, systems analysis, knowledge, notes, workflows and human interactions

Summary

Objective: The objective of this case report is to evaluate the importance of specialized domain knowledge when designing and using structured templated notes in a clinical environment.
Methods: To analyze the impact of specialization on structured note generation we compared notes generated for three scenarios: 1) We compared the templated history of present illness (HPI) for patients presenting with a dermatology concern to the dermatologist versus the emergency department. 2) We compared the evaluation of chest pain by ED physicians versus cardiologists. 3) Finally, we compared the data elements asked for in the evaluation of the gastrointestinal system between cardiologists and the liver transplant service (LTS). We used the SNOMED CT representation via BioPortal to evaluate specificity and grouping between data elements and specialized physician groups.
Results: We found few similarities in structured data elements designed by and for the specific physician groups. The distinctness represented both differences in granularity as well as fundamental differences in data elements requested. When compared to ED physicians, dermatologists had different and more granular elements while cardiologists requested much more granular data. Comparing cardiologists and LTS, there were differences in the data elements requested.
Conclusion: This case study supports the importance of domain knowledge in EHR design and implementation. That different specialities should want and use different information is well supported by cognitive science literature. Despite this, it is rare for domain knowledge to be considered in EHR implementation. Physicians with correct domain knowledge should be involved in the design process of templated notes.

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1. Introduction

In the Health Information Technology for Economic and Clinical Health Act (HITECH) portion of the American Recovery and Reinvestment Act of February 2009, Congress provides incentives for the adoption of electronic health records (EHR) [1]. More than just requiring the implementation of an EHR, HITECH is meant to promote meaningful use of EHRs. An increased use of structured data was identified by the Department of Health and Human Services in December of 2009 as one of the 15 core attributes of meaningful use in EHRs [2].

Structured data improves accessibility to historical quality measures, contributes to improved clinical workflow management, streamlines multisystem interoperability, and helps automate the coding process [3]. Structured data is also important for implementation of clinical decision support [4]. Templated notes have been advocated as the best way to capture structured data [5]. Unlike free text, templated notes allow the rapid recording of structured data by predetermining the questions that will be asked and constraining the answers [6].

This observational case report is based on our prior qualitative studies of physician user acceptance of the electronic health record [7, 8] and requests by physician groups to build templated notes using structured data. As part of a clinical terms project to build templated notes with structured data we observed that different physician groups were requesting different data elements even when evaluating the same organ system. We therefore set out to formally evaluate the similarities and differences between the data elements requested by different physician groups, i.e. physicians with different domains of practice and training. Domain knowledge is defined as an, "articulated, deep understanding of a domain, including the ability to reason and explain in casual terms, and to adopt multiple viewpoints about a problem or phenomenon [9]."

2. Objectives

The objective of this project is to evaluate the importance of domain knowledge when designing and using structured templated notes.

3. Methods

In January 2013 we conducted a systemic review of the medical literature utilizing the preferred reporting items for systemic reviews and meta-analysis (PRISMA) guidelines [10]. The methods of the analysis and inclusion criteria were specified in advance. We were searching for the use of domain knowledge in the electronic health record. Using the aid of the medical librarian, we searched for citations from PubMed/Medline, Google Scholar and Computer and Information Systems on the key words domain knowledge, electronic health record, health information technology, templated notes and structured data. After adjusting for duplications, this search identified 164 potential citations. Of these, 130 studies were discarded after reviewing the abstracts as they did not meet the inclusion criteria. Our inclusion criteria were potential relevance to domain knowledge, electronic health record, health information technology, templated notes and structured data. The remaining 34 were reviewed in detail by the two authors. These articles found from the PRISMA literature review as well as additional articles from medical decision-making, psychology and cognitive function literature over the past twenty years were obtained and served as the foundation for constructing this case report.

We evaluated the structured elements in the history of present illness documentation templates of the initial encounter created by and for four distinct physician groups at the University of Nebraska Medical Center (UNMC): the Division of Cardiology, the Liver Transplantation Service, the Emergency Department, and the Dermatology Department. The liver transplant service and cardiologists use Intuácare, an internally designed and developed EHR system while the ED uses Wellsoft. Dermatology developed a paper-based templated notes system.

Data requested by the ED and cardiology groups were in the setting of a patient presenting in the emergency department with chest pain. The liver transplant service and cardiology data were both from the setting of a clinical consultation. The comparison of structured dermatology notes compared patients presenting to the Emergency Department and the Dermatologist's office. In this case study, all structured data are categorized as common or domain specific.

Intuácare 1.0 and Wellsoft EDIS v10 are both electronic health records that support clinician designed templates. Created by the Department of Surgery at UNMC, Intuácare uses templated notes to collect and display clinical data. Structured data collected in these notes is stored in a local database and synchronized to an Oracle database [11]. A prose document containing the resultant note is then uploaded to the enterprise EHR without the structured data. Wellsoft is a commercially available information system created by the Wellsoft Corporation designed specifically for the Emergency Department using the chief complaint to drive template notes. Similar to Intuácare, Wellsoft allows physicians to design and implement individualized templated notes while storing the collected data on an Oracle database. The Emergency Department encounter note is stored in the Enterprise EHR. Dermatologists used paper-based templated note with structured data elements designed and implemented by the seven Dermatologists in the outpatient clinic.

We mapped the physician designed elements to published SNOMED CT elements. The Systematized Nomenclature of Medicine Clinical (SNOMED CT) is the latest iteration of a clinical coding system developed by the College of American Pathologists [12]. It is designed to support semantic interoperability using an ontology designed to describe pathology using topography, morphology, etiology, and function. SNOMED CT describes concepts using an onomasiological approach in order to allow relationships between these concepts [13].

We used Bioportal 2.0 to evaluate if the data elements could be represented in a logical tree structure [14]. Because of this design, SNOMED CT can be described visually with generic (IS-A) and partitive (PART-OF) relationships. In addition, SNOMED CT allows multiple concepts to be combined to provide a more complete representation of the concept as a clinical statement. The distinctive characteristics of SNOMED CT's concept system place the more generic concepts on the top level and the more specific concepts further down the tree, allowing for granularity [15]. Using this information about granularity, we were able to understand differences in specificity and grouping for the structured data elements used between specialties. For analysis we concentrated on three scenarios

1. We compared the templated notes for patients presenting with a dermatology concern to the dermatologist versus the ED.
2. We compared the evaluation of chest pain by ED physicians versus cardiologists.
3. Finally, we compared the elements used in the evaluation of the gastrointestinal system between cardiologists and the liver transplant service.

4. Results and Evaluation

We found few similarities in structured data elements designed by and for the specific physician groups. Those differences represented both differences in granularity as well as fundamental differences in data elements.

4.1 Dermatology versus Emergency Department

Dermatology and the emergency department evaluated the same system but in two different settings, the office and emergency respectively. Dermatology requested 46 data elements in their initial evaluation of patients presenting for evaluation while the ED requested only 7 data elements. As the ED requested 4 unique, more generic data elements, only 6.5% of dermatology elements overlapped with elements in Wellsoft. When data elements from the ED were compared with dermatology not only was the granularity different but a so was the setting of care. The ED notes focused on acute issues; rash, pruritus and foreign bodies while dermatology's evaluation had a much greater focus on moles, cancer and chronic diseases (▶Table 1).

4.2 Emergency Department versus Cardiology

The ED and cardiology evaluations used a common condition, chest pain, and a common setting in the emergency department. They had similar data elements but a difference in the total number of data elements defined for their templated notes. When comparing data elements in the evaluation of chest pain, the ED had 7 structured elements in Wellsoft. These elements are chest pain, dyspnea on exertion, paroxysmal nocturnal dyspnea, dizzy spells, syncope, palpitations, and edema of the lower extremities (▶Table 2). In addition, the ED clinicians designed the Wellsoft note to include areas for unstructured free text inputs such as intensity and characteristics of the chest pain. The cardiology templates were modeled in Intuácare using the ACC/AHA acute coronary syndrome guidelines and included 76 unique structured data elements [16]. Intuácare allows the collection and use of data on the same screen. Thus these templates were much more detailed and include data elements that support risk stratification by pertinent positive and negative findings and included decision support tools such as the TIMI risk stratification [17] (▶Figure 1).

4.3 Cardiology versus Liver Transplant Services

Cardiology and the liver transplant services examined a common system, the gastrointestinal system, in a common setting, the outpatient consultation. Both cardiology and liver transplant services created their templates in Intuácare. When gastrointestinal symptoms were evaluated some overlap was noted including nausea, vomiting, diarrhea, constipation, jaundice, abdominal pain, and gall bladder disease while unique data elements for liver transplant surgery of history of abdominal mass, hepatic ascites, pale stools, hematochezia, confusion, gastritis, melena, hematemesis and Tylenol ingestion. The only unique element of cardiology was cardiac ascites (▶Table 3).

5. Discussion

Different, independent physician groups request and use different data elements for their practice. ED physicians requested broad questions to cover a broad domain of potential diagnoses while cardiologists and dermatologists took a much deeper view of data. Further liver transplant services and cardiology providers approached a problem like ascites from fundamentally different perspectives (▶Figure 2 and ▶Figure 3).

Multiple studies have recognized the importance of models being specific to a limited application area [18-20]. For example cardiologists have no need to collect robust ophthalmological data and an ophthalmologist does not need to perform a complex chest examination [21]. O'Malley et al suggests that templates often are "too generic" and not appropriate for the history of present illness in a general medicine practice [22].

The importance of domain knowledge is well supported by cognitive science literature [23-25]. The advantages of understanding and utilizing domain specific data are plentiful. It increases both the efficiency of a physician's workflow [26] and patient outcomes [27].

A review of cognitive research studies on expertise has shown that experts in a specific domain are capable of perceiving large patterns of meaningful information in their domain that novices cannot perceive. They are faster at processing and at the deployment of different skills required for problem solving and have a superior short-term and long-term memory for materials related to their domain of expertise. Specialists typically represent problems in their domain at a deeper, more principled level, whereas novices show a more superficial level of representation [28]. Studies have shown that high domain knowledge individuals extrapolate more extensive information from material in their specific domain [29], have a more accurate recall of the data, and have the capacity to handle more data than low domain knowledge individuals [30-31]. Further, as described by Musen et al [32], maintenance of structured concepts to foster interoperability is aided with the support of domain knowledge. Therefore it should be expected that ED physicians, cardiologists, liver transplant specialists, and dermatologists request different data elements as they have very different specialized knowledge, practice environments and decision-making requirements [33].

In this study we noted significant differences in the granularity of structured data requested and generated by the generalized notes of ED physicians versus the specialized notes of cardiologists and dermatologists. Categorizing structured data more generally, ED physicians used a coarse-grained templated note to find the enabling conditions that allow them to determine if the chest pain was caused by heart disease [34]. Cardiologists used a fine-grained templated note to improve the diagnostic accuracy of the chest pain, risk stratification and inform treatment.

6. Conclusion

This study demonstrates that different physician groups' request and need different data elements for their work. Thus, a 'one-size-fits-all' templated note may not meet the distinct data needs of specialists and conversely hinder functionality for the generalist by requesting too much information and adversely affect physician workflow [35].

Although not directly related to templated notes and structured data collection an example of the functional importance of incorporating domain knowledge into the EHR configuration can be recognized in a 2004 study of the Children's Hospital of Pittsburg. The hospital rapidly implemented a commercially sold CPOE system in October of 2002 becoming one of the first children's hospitals to achieve 100% CPOE compliance status. CHP showed a decrease in the medication error rate and the level of adverse drug events. However, the mortality rate more than doubled [36]. Reviewers partially blamed the absence of domain specific ICU order sets for the increase in mortality [37].

This study may in part explain our findings of low physician satisfaction with current EHRs, even tech savvy super-users [38]. Understanding the importance of domain knowledge and user defined granularity of a templated note serves the specific physician's needs and can lead to an improvement in workflow [39]. When designing templated notes understanding the task and the target audience is critical. Physicians with correct domain knowledge should be involved in the design process.

Clinical Relevance Statement

There is low end-user satisfaction with current electronic health records. Our study demonstrates that different physicians want and use different structured data. This underscores the importance of domain knowledge and involving physicians in the design of EHR functionality.

Conflict of Interest

There were no conflicts of interest

Human Subjects Protections

There were no human subjects. Our research was deemed exempt under 45 CFR 46:101b, category 4 (existing data without PHI) by the Office of Regulatory Affairs Institutional Review Board at the University of Nebraska Medical Center.

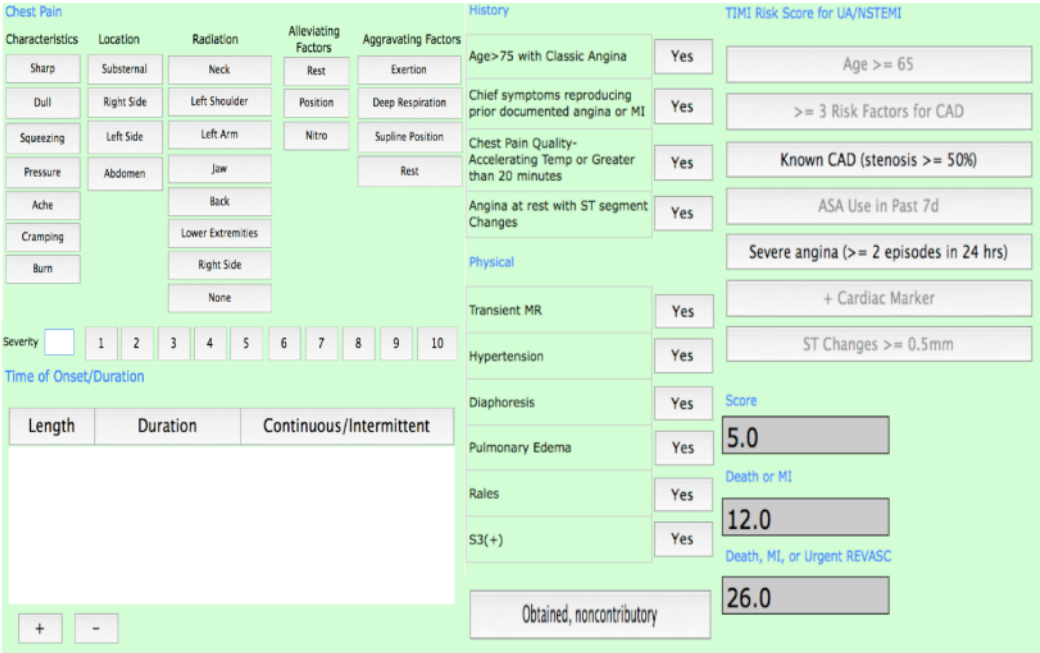

Fig. 1 This figure is taken from an Intuácare screen for the cardiologist's evaluation of chest pain. Not only is chest pain categorized in detail certain additional conditions such as "age greater than 75 with classic angina" or the TIMI risk score help the clinician risk stratify the patient.

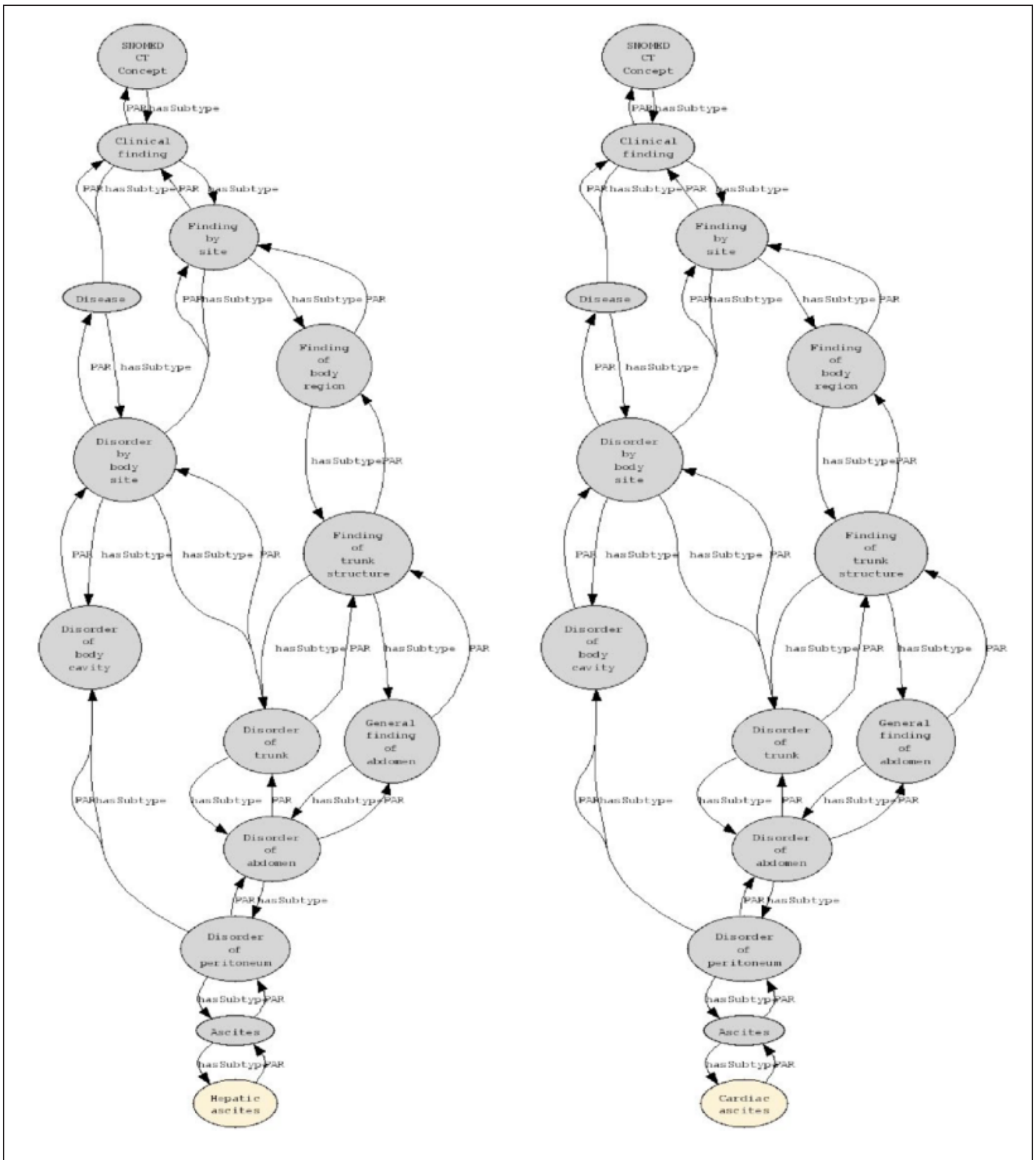

Fig. 2 This figure compares hepatic and cardiac ascites. The share a common structure to the final element, however, they share no common pathophysiologic base.

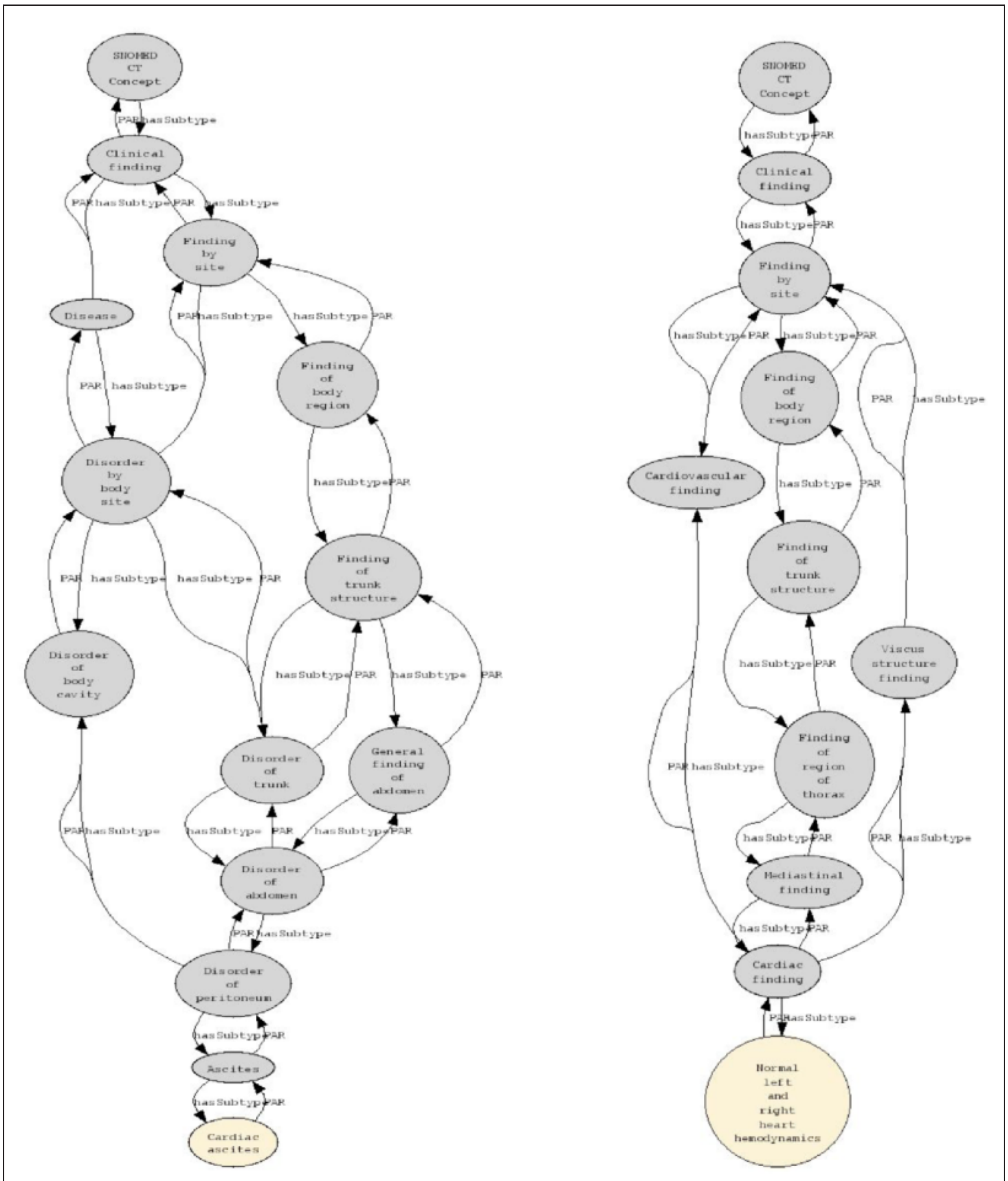

Fig. 3 This figure compares cardiac ascites and heart hemodynamics. Despite a common pathophysiologic base they share no common elements beyond „finding of trunk structure".

Table 1 The comparison of Dermatology and Emergency Department data elements

Common Elements	Dermatology Elements	Emergency Department
Organ Transplantation	Blood Thinners	Rash
Alcohol Use	Drug Allergies	Puritis
Smoking History	Latex Allergy	Foreign Bodies
	Intolerance to Dental Anesthesia	Swelling
	Medication History	
	Change in Skin Spot	
	Hives	
	Shortness of Breath	
	Arthritis	
	Autoimmune Disease	
	Basal Cell Carcinoma	
	Biopsy of an Abnormal Mole	
	Cancer	
	Hepatitis B	
	Hepatitis C	
	HIV/AIDS	
	Melanoma	
	MRSA	
	VRE Infection	
	Radiation Treatment	
	Squamous Cell Carcinoma	
	Blistering Sunburn	
	Reaction to Sun	
	Antibiotic Use	
	Mohs Surgery	
	Abnormal Moles	
	Asthma	
	Lupus	
	Rheumatoid Arthritis	
	Thyroid Problems	
	Eczema	
	Family History of Abnormal Moles	
	Family History of Asthma	
	Family History of Lupus	
	Family History of Rheumatoid Arthritis	
	Family History of Thyroid Problems	
	Family History of Eczema	
	Family History of Melanoma	
	Use of Sunscreen	
	Use of Tanning Beds	
	Smoking History	
	Current Pregnancy	
	Breast Feeding	
	Birth Control	

Table 2 Emergency Department Cardiology Data Elements

Common Elements	Cardiology Elements	Emergency Department
Syncope	Sharp Pain	Chest Pain
Palpitations	Dull Pain	Dyspnea on Exertion
	Squeezing Pain	Paroxysmal Nocturnal Dyspnea
	Chest Pressure	Dizzy Spells
	Ache	Edema of the Lower Extremities
	Chest Cramping	
	Chest Burn	
	Substernal Pain	
	Right Side Pain	
	Left Side Pain	
	Abdominal Pain	
	Radiating to Neck	
	Radiating to Left Shoulder	
	Radiating to Left Arm	
	Radiating to Jaw	
	Radiating to Back	
	Radiating to Lower Extremities	
	Radiating to Right Side	
	Radiating to None	
	Alleviated by Rest	
	Alleviated by Position	
	Alleviated by Nitro	
	Aggravated by Exertion	
	Aggravated by Deep Respiration	
	Aggravated by Supline Position	
	Aggravated by Rest	
	Pain Severity	
	Length of Onset	
	Duration	
	Continuous/Intermittent	
	Age>75 with Classic Angina	
	Chief symptoms reproducing prior documented angina or MI	
	Chest Pain Quality- Accelerating Temp or Greater than 20 minutes	
	Angina at rest with ST segment Changes	
	Transient MR	
	Hypertension	
	Diaphoresis	
	Pulmonary Edema	
	Rales	

Table 2 Continued

Common Elements	Cardiology Elements	Emergency Department
	S3(+)	
	Age≥65	
	≥3 Risk Factors for CAD	
	Known CAD (stenosis ≥50%)	
	ASA Use in Past 7d	
	Severe angina (≥2 episodes in 24 hrs)	
	Positive Cardiac Markers	
	St Changes ≥0.5 mm	
	TIMI Risk Score	
	Death or MI %	
	Death, MI, or Urgent REVASC %	
	Angina	
	Angina Grade (CCS)	
	Heart Failure Class (NYHA)	
	History of Hypertension	
	History of Dyslipidemia	
	History of Diabetes	
	History of Tobacco Use	
	History of Chronic Lung Disease	
	History of Chronic Kidney Disease	
	History of Dialysis	
	History of Illicit Drug Use	
	History of Atrial Arrhythmias	
	History of Ventricular Arrhythmias	
	History of Depression	
	History of Coronary Artery Disease	
	History of Cerebral Artery Disease	
	History of Peripheral Artery Disease	
	History of Aorta Disease	
	History of Renal Artery Disease	
	History of Myocardial Infarction	
	Date of Myocardial Infarction	
	History of Sudden Cardiac Arrest	
	History of Heart Failure	
	Family History of Coronary Artery Disease	

Table 3 The Comparison of Liver Transplant Service and Cardiology Data Elements

Common Elements	LTS Elements	Cardiology Elements
Nausea	Hepatic Ascites	Cardiac Ascites
Vomiting	Pale Stools	
Diarrhea	Hematochezia	
Jaundice	Confusion	
Abdominal Pain	Gastritis	
Mass	Melena	
Constipation	Hematemesis	
Gall Bladder DX	Tylenol Ingestion History	

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