# A META-ANALYSIS CODEBOOK TO ASSESS THE RELATIONSHIP BETWEEN EHRS AND HEALTH OUTCOMES

By

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CERTIFICATE OF APPROVAL

This is to certify that the Master's Capstone Project of

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*A Meta-Analysis Codebook to Assess the Relationship between EHRs and Health Outcomes*

Has been approved

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*"Knowing is not enough; we must apply. Willing is not enough; we must do."*
—Goethe

# Abstract

**Background**: Health information technologies (HIT) such as electronic health records (EHRs), computerized provider order entry (CPOE) systems. clinical decision support systems (CDSS), and integrated guidelines based systems are key to improving quality of health care.

**Purpose**: The aim of this capstone was to create a codebook that can be used to code articles to conduct a meta-analysis that would be aimed at reviewing the evidence available about the use of HIT/EHRs/CDSS/CPOE on patient and health outcomes.

**Data Sources**: SCOPUS, MEDLINE, CINAHL, Cochrane Central Register of Controlled Trials covering a period from January 1, 1996 to March 31, 2013.

**Results**: A new application was developed to take data from all the above mentioned databases. In comparison to RefWorks this application performed with superior accuracy and was able to de-duplicate and merge datasets with ease. The result was 47,364 unique abstracts after the process of de-duplication was completed. The codebook was created based on the sample of 106/565 studies identified through SCOPUS. The resulting codebook contains eight sections: study characteristics, eligibility, methods, participants, interventions, outcomes, results, and miscellaneous.

**Limitations**: This codebook was based on 106 studies, so some variables may still need to be added or modified to develop a comprehensive codebook.

**Conclusion**: Over 70 thousand studies have been published about the benefits of HIT. Given this large volume of studies, it is time to synthesize these results in a meaningful

and unbiased manner. Meta-analysis is the most appropriate method for synthesizing a vast body of information so that the field is able to meaningfully use this synthesized information. We believe that this codebook will at least shorten the time needed for conducting a comprehensive by 6-9 months.

# Chapter 1- Introduction

According to the 2011 World Bank data, United States (US) has a population of 311.6 million with a Gross Domestic Product (GDP) of 14.99 trillion US dollars and a life-expectancy of 79 years (http://data.worldbank.org/country/united-states). Health care expenditures constitute 17.9% of the GDP and we were spending $8,608 per capita in 2011. Every year healthcare spending is a larger part of the GDP than the year before.

Concern about people's experience with health care and the related expenses are well documented. Still people continue to experience poor quality of care in the US despite the highest per capita expenditure on the delivery and management of health care. For instance, only one in two people receive recommended care (McGlynn *et al*., 2003), and medical errors are the fifth leading cause of death in the United States (Institute of Medicine Committee, 2001). A World Health Organization (WHO) report ranked the US health system 37$^{th}$ among 191 countries that were ranked, with France being ranked No. 1 (Murray and Frenk, 2010).

A majority of U.S. health care consumers are dissatisfied with their levels of access to their physicians and to their medical records; 57% of respondents with internet access wanted to email their doctors but were unable to, and 75% wanted access to their own medical records but were unable to access them (Davies *et al*., 2008; Davis & Commonwealth Fund, 2006). The US, despite spending the most money on a per capita basis, was ranked seventh (Refer Figure 1) out of seven countries for patient safety, patient-centeredness, efficiency, and equity in a study comparing it with Australia,

Canada, Germany, New Zealand, and the United Kingdom (The Commonwealth Fund Report, 2010).

Figure 1: Comparing US with Six Other Countries on Health Quality

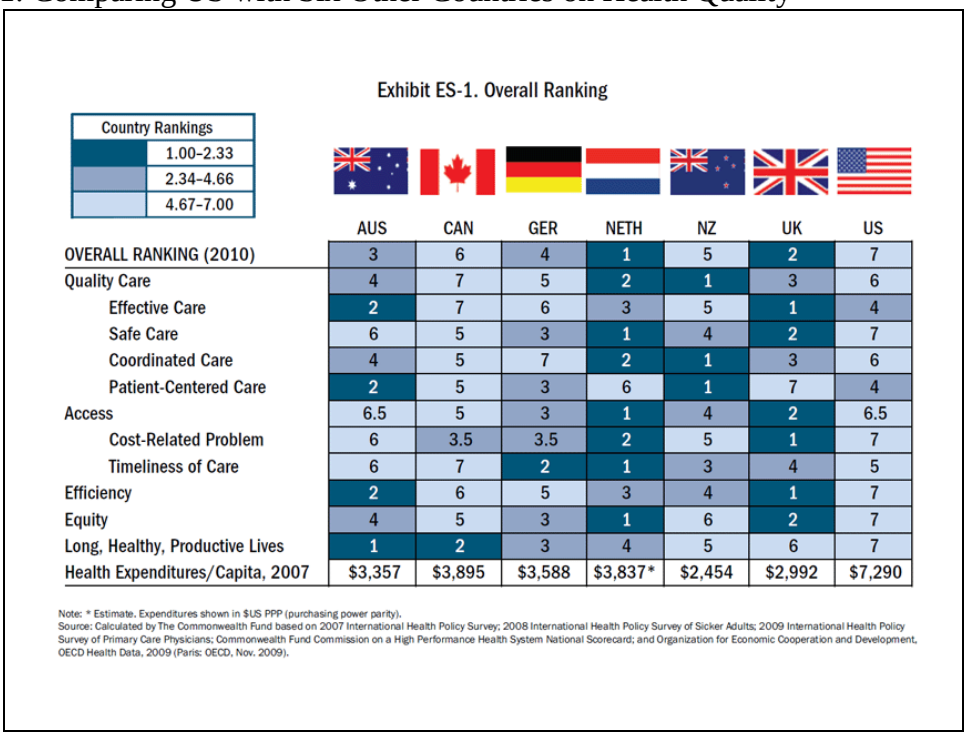


Exhibit ES-1. Overall Ranking

| Country Rankings |
|---|
| 1.00–2.33 |
| 2.34–4.66 |
| 4.67–7.00 |

| | AUS | CAN | GER | NETH | NZ | UK | US |
|---|---|---|---|---|---|---|---|
| OVERALL RANKING (2010) | 3 | 6 | 4 | 1 | 5 | 2 | 7 |
| Quality Care | 4 | 7 | 5 | 2 | 1 | 3 | 6 |
| Effective Care | 2 | 7 | 6 | 3 | 5 | 1 | 4 |
| Safe Care | 6 | 5 | 3 | 1 | 4 | 2 | 7 |
| Coordinated Care | 4 | 5 | 7 | 2 | 1 | 3 | 6 |
| Patient-Centered Care | 2 | 5 | 3 | 6 | 1 | 7 | 4 |
| Access | 6.5 | 5 | 3 | 1 | 4 | 2 | 6.5 |
| Cost-Related Problem | 6 | 3.5 | 3.5 | 2 | 5 | 1 | 7 |
| Timeliness of Care | 6 | 7 | 2 | 1 | 3 | 4 | 5 |
| Efficiency | 2 | 6 | 5 | 3 | 4 | 1 | 7 |
| Equity | 4 | 5 | 3 | 1 | 6 | 2 | 7 |
| Long, Healthy, Productive Lives | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Health Expenditures/Capita, 2007 | $3,357 | $3,895 | $3,588 | $3,837* | $2,454 | $2,992 | $7,290 |

Note: * Estimate. Expenditures shown in $US PPP (purchasing power parity).
Source: Calculated by The Commonwealth Fund based on 2007 International Health Policy Survey; 2008 International Health Policy Survey of Sicker Adults; 2009 International Health Policy Survey of Primary Care Physicians; Commonwealth Fund Commission on a High Performance Health System National Scorecard; and Organization for Economic Cooperation and Development, OECD Health Data, 2009 (Paris: OECD, Nov. 2009).

Source: The Commonwealth Fund Report, 2010

More than a decade ago, the Institute of Medicine (IOM) published two reports describing the United States' lack of quality health care and the alarming proportions of patient morbidity and mortality attributable to medical errors (Carroll, 2002). Within these reports, the IOM made specific recommendations for improving the quality of health care, proposing strategies for advancing the health care system by focusing on the six aims of quality health care, namely, safety effectiveness, patient-centeredness, timeliness, efficiency, and equity (Carroll, 2002). The IOM report also identified seven challenges related to the achievement of good quality health care: re-engineered care processes; effective use of information technologies; knowledge and skills management;

development of effective teams; coordination of care across patient-conditions and service sites over time; and making change possible.

Effective use of health information technologies (HIT) in medicine should play a critical role in achieving better and more cost-effective care. HIT can provide an infrastructure to measure indicators that allow us to determine when we have reached our goal of "quality healthcare for all." For improved measurement we need better data in digital form. To this end, there has been an increase in the number of health providers collecting health data electronically in the past two decades; the goal has been to replace paper-based processes with electronic ones. This switch to electronic data storage and processing has resulted from advances in security, falling hardware prices, and exponential increases in processing speed and data storage.

In the early stages of HIT, it was assumed that all of the challenges of delivering quality health care would be addressed by implementing electronic health records (EHRs); this assumption over-estimated EHRs' actual impact. Now we know that the mere adoption of HIT solutions will not improve services in the absence of policies focused on improving quality of care (Diamond and Shirky, 2008). In summary, the EHR should be thought of as a tool to facilitate informed discussions about how new programs can be designed to improve health outcomes and address issues of equity and disparities.

Concurrently, the Healthy People 2000, 2010 and now 2020 initiatives have focused on addressing disparities and utilizing HIT to identify the social determinants associated with disparities as well as eliminating disparities and improving health of all groups. One of the proposed goals of Healthy People 2010 (US Department of

Health and Human Services, 2010) was that each person should have access to his or her health information by 2012. This goal was not achieved, though substantial progress is being made toward adoption of EHRs at the practitioner level.

**EHRs and the Health Information Technology for Economic and Clinical Health Act**

ONC defines EHRs as:

> "…at their simplest, digital (computerized) versions of patients' paper charts. EHRs are real-time, patient-centered records. They make information available instantly, 'whenever and wherever it is needed'. And they bring together in one place everything about a patient's health."

EHRs can:

- Contain information about a patient's medical history, diagnoses, medications, immunization dates, allergies, radiology images, and lab and test results
- Offer access to evidence-based tools that providers can use in making decisions about a patient's care
- Automate and streamline providers' workflow
- Increase organization and accuracy of patient information
- Support key market changes in payer requirements and consumer expectations
- One of the key features of an EHR is that it can be created, managed, and consulted by authorized providers and staff across more than one health care organization (ONC website, 2013).

In 2009, through the American Recovery and Reinvestment Act (ARRA), Congress appropriated approximately $20 billion to implement the Health Information Technology for Economic and Clinical Health Act (HITECH) and another $30 billion in incentive payments to eligible providers for adoption of certified electronic health records (EHRs). The Office of the National Coordinator (ONC) was charged with implementing

the HITECH Act. ONC developed a multi-pronged approach to achieve the HITECH Act's goals.

They state that:

> "The Health Information Technology for Economic and Clinical Health (HITECH) Act seeks to improve American health care delivery and patient care through an unprecedented investment in HIT (HIT). The provisions of the HITECH Act are specifically designed to work together to provide the necessary assistance and technical support to providers, enable coordination and alignment within and among states, establish connectivity to the public health community in case of emergencies, and assure the workforce is properly trained and equipped to be meaningful users of certified Electronic Health Records (EHRs). These programs collaboratively build the foundation for every American to benefit from an EHR as part of a modernized, interconnected, and vastly improved system of care delivery." (ONC website 2013, underline added)

One advantage of the HITECH Act is that the HIT industry has had to get together and agree to develop and adopt certification and standards to realize the goal of inter-operability across platforms. Initially, HIT systems were implemented in the absence of defined standards. This led to the development of many proprietary solutions that were unique to the specific agencies or programs. Recently, the number of EHR vendor solutions has increased several folds. Many more turn-key choices are available to hospitals, ambulatory health care practices, and other specialty practices now than five years ago.

As HIT standards are being established for the health industry, many specialty providers (*e.g.* such as the behavioral health, long-term-care, and nurses) continue to struggle with their unique needs and government mandates regarding medical records.

These providers were left out of the funds made available through the HITECH Act to eligible providers and hospitals. Diamond and Shirky (2008) remind us that just having HIT standards does not mean that they will be implemented. They posit that the focus on standards is misplaced primarily for "social / technical problems (*e.g.* communication) that include: 1) The "felt need" for adopting standards; 2) compelling reasons for sharing information; 3) the difficulty of developing information policies that support technology standards; and 4) the fact that development of EHR solutions is outpacing the development of applicable standards. Consequently, many solutions are being developed in the absence of standards. The difficulty of designing systems that easily connect with each other and exchange data still remains as the greatest challenge to interoperability and consequently patient care.

**Potential benefits associated with EHR use**

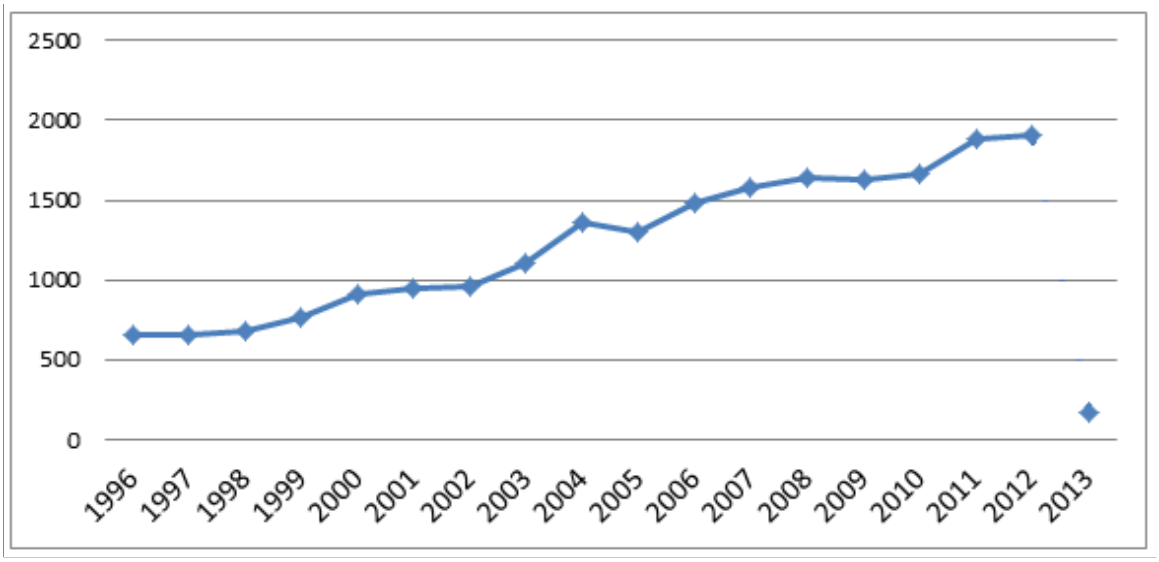
The ONC website (www.healthit.gov) has provided much insight and guidance into what is seen as certified EHR technologies and Centers for Medicare and Medicaid Service (CMS) has provided evolving guidance on what "meaningful use" of EHRs means. Despite the much discussed potential of benefits as a result of EHR implementation, conclusive evidence is still lacking in what is seen as indisputable case for return on investment (ROI) and improved patient outcomes as a result of EHR implementation.

Much has been written about the benefits of EHRs, Electronic Medical Records (EMR), and Computerized Patient Records in the published peer-reviewed and gray literature. Given that health data has been captured electronically for at least three

decades, we believe that there should be sufficient evidence to ascertain whether or not implementing EHRs leads to improved system or patient outcomes. To this end we think that it is timely to conduct a meta-analysis based on the last 25 years of articles published related with EHRs and HIT. The proposed meta-analysis would help fill in gaps in our HIT landscape. It may identify areas where we have established beyond doubt patient- and/or system-level outcomes or identify areas where additional studies are needed to establish the evidence of benefits. We may learn that EHR adoption is just a first step and that the real benefits can only be realized when we add features such as clinical decision supports (i.e. alerts, reminders, notifications) associated with evidence-based-practices (EBPs), guideline-based care, and computerized provider order-entry (CPOE) systems.

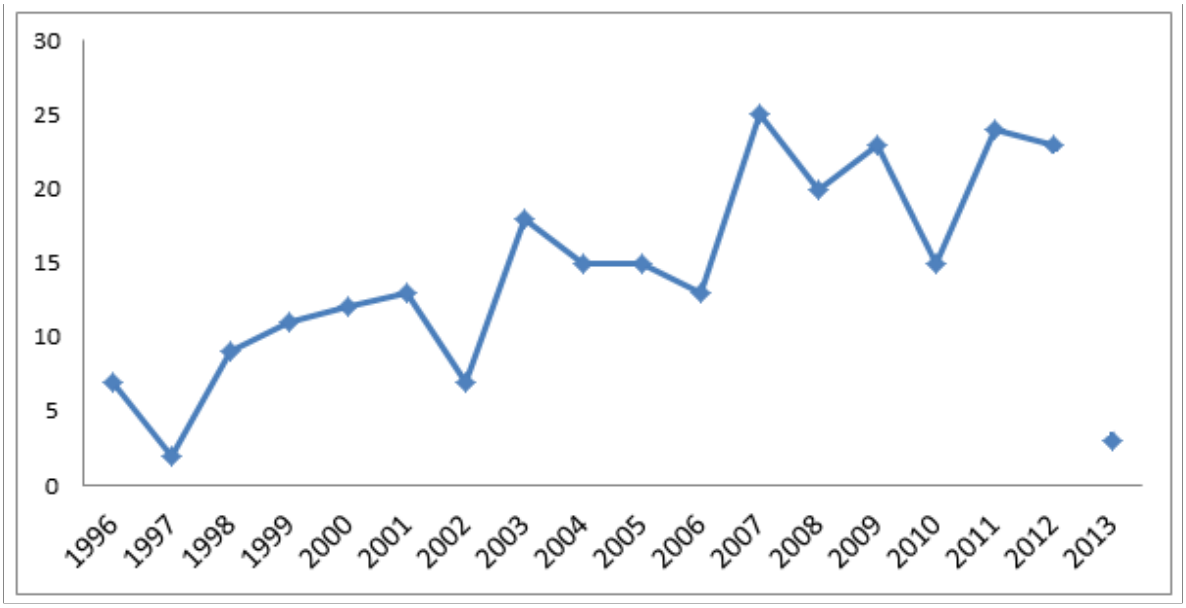
Since the implementation of the HITECH Act, there has been a doubling of the adoption of EHRs among physicians and hospitals. But, it is still difficult to establish a causal relationship between implementation of EHRs and better patient or system outcomes. The last few years have seen a tremendous increase in the number of review, systematic review, and other kinds of review articles that focus on the *potential* benefits of EHRs, refer to Figure 2 and Figure 3.

Figure 2: Number of EHR/Health Information Exchange (HIE) Meta-Analysis References that were Reviews written between 1996-2013




Note: The 2013 data point is only for the first three months of data

Figure 3: Number of EHR/HIE Meta-Analysis References found for Meta-Analysis written between 1996-2013




Note: The 2013 data point is only for first three months of data

The number of studies that conclude with the statement on the potential benefits of EHRs far exceed studies that report conclusive evidence that supports the EHR benefits. We summarize the many potential benefits associated with adoption and use of EHRs on health care quality in Table 1 (ONC website, 2013).

Table 1: Summary of potential EHR benefits for providers and patients

| **Benefits of EHRs for providers** | **Benefits of EHRs for patients** |
|---|---|
| Accurate and complete information about patient's health | Create an avenue for communication |
| The ability to quickly provide care | Reduced need to fill out the same forms at each office visit |
| The ability to better coordinate care they give | Reliable point-of-care information and reminders notifying providers of important health interventions |
| A way to share information with patients and their family caregivers | Convenience of e-prescriptions electronically sent to pharmacy |
| Quick access to patient records from inpatient and remote locations for more coordinated, efficient care | Patient portals with online interaction for providers |
| Enhanced decision support, clinical alerts, reminders, and medical information | Electronic referrals allowing easier access to follow-up care with specialists |
| Performance-improving tools, real-time quality reporting | |
| Legible, complete documentation that facilitates accurate coding and billing | |
| Interfaces with labs, registries, and other EHRs | |
| Safer, more reliable prescribing by flagging dangerous drug interactions, verifies medications and dosages, and reduces the need for potentially risky tests and procedures. | |
| Access experts for rural health care providers by sharing best practices and allowing for specialized care through telemedicine | |
| Standardization of data, order sets, and care plans helping to implement common treatment of patients using evidence-based medicine | |
| Better integration among providers by improved information sharing | |
| Convenient, faster, and simpler disease management | |
| Population management trended data and treatment and outcome studies | |
| Viewable and up-to-date medication and allergy lists | |
| Order entry at point of care or off-site | |

A key goal of EHRs is to simplify care providers' jobs and to facilitate better client care using centrally-available electronic information. If individuals can carry a portable EHR when seeking treatment, then care providers will be able to provide and coordinate appropriate treatment. This portability assumes a level of inter-operability between systems that has not yet been realized.

Despite the advances in the HIT field and many articles espousing the advantages of EMRs, the evidence of the advantages of EHR/EMR adoption are mixed. For instance, Zhou (2009) concludes that there was no difference in performance on 18 quality measures representing six disease conditions between physicians that used EHRs and non-users of EHRs. In addition, adoption rates are relatively low. Only 4% of the physicians have an extensive, fully-functional electronic system, while 13% report having some basic system (DesRoches *et al*., 2008). A 2011 national study reports a 57% EHR adoption rate among office-based physicians (Hsiao, 2011). This rate is even higher among family physicians at 67.8% (Xierali *et al*, 2013).

Some of the advantages of EHR adoption found in the peer-reviewed literature are centered on the themes of accuracy, quality, reduced costs, and task automation. Advantages include:

- Accurate medication lists, legible notes and prescriptions, immediately available charts, enhancement of health care delivery, facilitation in decision-making, and the ability to reduce medication errors via alerts delivered by the use of inpatient Computerized Physician Order Entry Systems (Galanter *et al*, 2008).

- The ability to mine text information for improved and appropriate billing, thus increasing revenues (Gonzalez and Puri, 2008).
- Communication across providers resulting from the implementation of summary patient records (Bart and Hannan, 2007).
- The potential for improving the quality of care and physicians' and practices' efficiency due to increased access to stored medical information, with the concomitant ability to conduct outcome studies (Fitzgerald *et al*., 2007).
- The ability to calculate prevention costs using standardized measures (Vogt *et al*., 2007).
- The ability of nurses to spend more time with clients (Choi *et al*., 2006).
- Savings from preventing adverse drug events were estimated at $4.64 billion in the US VA system (Center for IT leadership, 2010).
- Use of HIT to provide access to health information for Emergency medical professionals (Finnell and Overhage, 2011).
- Reminders generated based on patient medical history can improve quality of care (Persell et. al, 2011).

On the other hand, many challenges and barriers to the adoption of EMRs and EHRs have been identified despite the early enthusiasm by practitioners and

significant public expenditures spent on facilitating adoption. These challenges include:

- Limited evidence that the EMR improves quality of care (Kazley and Ozcan, 2008). Screening and sending results electronically to PCTPs integrated into EMRs had little differential impact on three- and six-month clinical outcomes or on process measures for treating depression (Rollman *et al*., 2002).
- The use of an EMR during primary care was insufficient for insuring high-quality. Practices not using the EMR were more likely to meet guidelines for process, treatment, and intermediate outcomes (Crosson *et al*., 2007).
- Costs, complex systems, lack of data standards, privacy concerns, and legal barriers hinder adoption (Anderson, 2007).
- Dysfunctional communication patterns, distribution of formal and informal decision-making power, and internal conflicts (Crossman *et al*., 2005).
- The high cost and complexity of quality improvement (Miller and Sim, 2004).

Despite the publication of over 75,000 articles and 30,000 reviews since the early 1990s on the topic of HIT and improvement of care, a definitive answer about the value of EHR implementation has not been found. The jury is still out on the fundamental efficacy of EHR adoption for improving the quality of care to patients.

Systematic reviews and meta-analysis are two analytic methods that allow for the evaluation of a large body of evidence in the research literature. They summarize

the results of many studies and help present findings based on the evaluation of an overwhelming amount of information in a succinct way so that it can be consumed and effectively utilized by practitioners and researchers. We believe that given the voluminous amount of information being published we should be able to answer the question about the value of EHRs conclusively and that meta-analysis is the appropriate tool for such an analysis.

**Meta-analysis**

Both systematic reviews and meta-analysis involve comprehensive surveys of a research topic or question with an explicit, systematic, and reproducible methodology for summarizing a large body of literature. Both are extremely labor intensive and may take years to conduct. The meta-analysis; however, is at the top of the *evidence-pyramid* because it includes a statistical analysis (Downstate Medical Center SUNY website, 2013). The meta-analysis term was first used in 1976. Meta-analysis is, "a quantitative statistical analysis of several separate but similar experiments or studies in order to test the pooled data for statistical significance."(Merriam-Webster dictionary online, 2013).

Guidelines for conducting systematic reviews and meta-analysis were promulgated in 2009, titled the PRISMA Statement (Moher, Liberati, Tetzlaff, Altman, 2009; Liberati, Altman, Tetzlaff *et al*., 2009) which replaced the 1996 Quality of Reporting of Meta-analyses (QUOROM) statement. For almost every decade, a review on the quality of "reviews" has been published. And it shows the same result, that, most of the published systematic reviews are of suboptimal quality. The PRISMA statement adopts the Cochrane Collaboration definition for systematic reviews and meta-analysis.

The fundamental difference between the two is the use of statistical methods which is a must when conducting meta-analyses:

> "A review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review. Statistical methods (meta-analysis) may or may not be used to analyse and summarise the results of the included studies." (page 45, CC Glossary version May 2005)

A meta-analysis is used to address and compile all pertinent studies conducted (*i.e.* correlation, observational, and randomized control trials) that contribute quantitative evidence. In our case we want to conduct a meta-analysis to answer the question regarding the relationship between EHRs and patient- and system-level outcomes. Researchers do not often undertake meta-analysis because it is time-consuming, labor intensive, and new evidence and literature is being added to the universe of studies that are in the base pool of studies that comprise the universe of eligible studies. Typically, a meta-analysis takes between one and three years to complete and require a team of researchers.

In the last five years we have seen an increase in the number of systematic reviews that are being published on EHRs. Researchers usually stop at systematic reviews as they are easier to implement and complete than meta-analysis. There were several relevant systematic reviews but none of the studies were based on a meta-analysis. The Annals of Internal Medicine, has published a few relevant systematic reviews (SR) pertaining to EHRs and other HIT, for example, "Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical

Care" was published in 2006 (Chaudhury *et al*.) and then another titled "Effect of Clinical Decision-Support Systems: A systematic review" published in 2012 (Bright *et al*.). Bright *et al*. concluded that the evidence for clinical, economic, and efficiency outcomes associated with use of CDSS's remains sparse. The limitations of the mainly narrative systematic reviews are that conflicting results remain unresolved and that vote counting is inadequate in terms of representing underpowered and over-powered studies.

These limitations can be off-set by the benefits of a meta-analysis which include the use of effect-sizes to increase power and precision by combining small underpowered primary studies; it avoids excessive emphasis on *p* values in overpowered studies; and it gives more weight in analysis to larger studies. By capturing all the relevant study characteristics in a codebook, the researchers have the ability to examine study features that are associated with differences in effect sizes, which may not have been studied or reviewed in the primary study. Another advantage is the ability to compare multiple interventions and outcomes in a comprehensive and systematic way. Lastly, it provides reliable evidence for suggesting future research and practice questions that are guided by evaluating the comparative effectiveness of HIT on outcomes. A preliminary investigation of the literature found that n*ot even a single meta-analysis has been conducted on this topic.*

Because a comprehensive and complete meta-analysis is out of the typical scope and size of a Master's level capstone project, this project aims to address key analytic and logistical issues related to the creation of a meta-analysis to evaluate the unanswered question of whether EHR adoption provide better health care outcomes. The main aim of this project is to create a codebook for the meta-analysis to help answer the question:

does adoption of EHRs and other HIT technologies result in improved patient- and system-level health outcomes.

The creation of a comprehensive codebook through a review of the EHR literature is the first step toward conducting a meta-analysis and is a pragmatic component in the development of this meta-analysis. This codebook will give the research community an instrument to code the articles/reports in a meaningful way and help answer a fundamental question about the relationship (*i.e.* associative or causal) between EHRs and their resulting impact on improvement in both the process of health care delivery and health outcomes. Also, having a published codebook can help in a continued coding of articles which makes the process of keeping the meta-analysis current more realistic despite the continual production of research on the topic. In summary, this capstone is focused on creating a codebook that would be useful to everyone that is currently working on evaluating the evidence to assess the impact of HITECH on quality of care.

# Chapter 2 – Methods

As a first step, the author undertook a one-week intense course in Meta-Analysis at the University of Missouri, Sinclair School of Nursing from June 11-15, 2012. Listed below are the steps we took to create the knowledge base to develop a comprehensive codebook to undertake a meta-analysis to assess the evidence to date on the association between adoption and use of EHRs and system and patient outcomes.

We also decided to use the PRISMA 2009 Flow Diagram for identifying, screening, determining eligibility, and making a final determination to include studies in the meta-analysis. Consequently, we will follow the PRISMA 2009 where relevant.

A literature review was conducted to ascertain if there were sufficient studies that had been conducted to answer the question, "Is there a relationship between EHR/HIT implementation and system and patient outcomes?" A preliminary search in PubMed and Scopus resulted in many hits. Upon examination of the abstracts it was clear that a meta-analysis on this topic was timely as none had been conducted. After having established the viability and soundness of the research question we determined that the next step was to review the abstracts and create the codebook that would be used to code the articles that were selected for being in the study.

We worked with Kathleen Crea, MLS, 6$^{th}$ Year, AHIP, Information & Education Services Librarian at the University of Connecticut Health Center, to create the string of search terms that we would use to search for abstracts and studies systematically in the literature. Initially, we selected the following sources for searching PubMed, Scopus and

EMBASE, CINAHL, Cochrane Central Register for Controlled Trials, PsycInfo, Dissertation Abstracts International, Web of Science, and Google Scholar. The librarian worked over a period of six-months to create these search strings for each of the identified databases. This meta-analysis is based on searches covering the period between 1/1/1996 and 3/31/ 2013. We used 1996 as the starting period as the initial review of literature yielded 1996 as the year when we started seeing articles on electronic patient records. For this capstone, no hand- or gray literature-searches were conducted

The main search string was based on the basic assumption that we wanted to ensure that all studies that had used electronic patient records and reported quantifiable outcomes was selected in. We used the following logic to select the studies into our total universe for abstraction and evaluation. A simple expression of the logic we applied can be represented by ("EHR/Patient/clinical reporting systems" AND (Patient AND/OR System Outcome)). How these strings were translated to be used in each of the identified databases is summarized in Table 2.

Table 2: Databases and Query Strings

| **Name of Database/Filters** | **Query String** |
|---|---|
| **CINAHL** | ( ((MH "Health Information Management") OR (MH "Electronic Data Interchange") OR ("Clinical Decision Support System*") OR ("Decision Support Technique*") OR ("Decision Support Systems Management") OR (MM "Clinical Information Systems") OR (MH "Health Information Systems") OR (MM "Decision Support Systems, Clinical") OR (MH "Hospital Information Systems") OR (MH "Clinical Information Systems") OR ("Medical Order Entry System*") OR ("health information technolog*") OR ("hospital information system*") OR ("clinical decision support") OR (CDSS) OR ("health care decision support") OR ("healthcare decision support") OR (MH "Management Information Systems") OR (MH "Health Information Systems") OR (MH "Electronic Data Interchange") OR (MM "Managed Care Information Systems") OR (MH "Health Information Management") OR (MH "Health Care Information Exchange (Iowa NIC)") OR (MH "Electronic Data Interchange") OR (MH "Health Information Networks") OR (MH |

| Name of Database/Filters | Query String |
|---|---|
| | "Health Information Systems") OR (MH "Consumer Health Information") OR (MH "Health Information Management Service") OR (MH "Health Plan Employer Data and Information Set") OR (MH "Record Review") OR (MH "Medical Records") OR (MH "Medical Record Linkage") OR (MH "Electronic Order Entry") OR (patient order entry) OR (POE))<br>OR<br>((health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR Health Records Personal OR Personal Health Record OR ehealth OR e-health OR E-health OR medical informatics application* OR medical records system* OR medical records system computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR Electronic Health Record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record*))<br>)<br>AND<br>(<br>((MM "Cost Benefit Analysis") OR (MM "Costs and Cost Analysis") OR (MM "Health Care Costs") OR (MM "Health Care Delivery, Integrated") OR (hospital cost*) OR (MM "Outcomes (Health Care)") OR (MM "Health Services Needs and Demand") OR (MM "Adverse Health Care Event") OR (MM "Health Care Delivery") OR (MM "Outcome Assessment") OR (MM "Patient Centered Care") OR (MM "Continuity of Patient Care") OR (MM "Progressive Patient Care") OR (MM "Quality of Care Research") OR (MH "Quality of Care Research") OR (MM "Quality of Health Care") OR (MM "Cost Control") OR (MM "Cost Savings") OR (MM "Economic Aspects of Illness") OR (MM "Process Assessment (Health Care)") OR (MM "Quality Assessment") OR (MM "Quality Control (Technology)") OR (MM "Health Screening") OR (MH "Continuity of Patient Care"))<br>OR<br>(("Electronic Prescribing") OR ("Clinical Pharmacy Information System*") OR (electronic prescription*) OR (electronic prescribing) OR e-prescription* OR e-prescribing OR (prescribing error*) OR (medication system*) OR (clinical pharmacy information service*) OR (“computerized physician order entry system*”) OR (“computerized patient order entry system*”) OR CPOE OR (computerized prescribing) OR (computerized prescription*) OR (drug monitoring) OR (adverse drug event*) OR (drug administration) OR (medication error*) OR (adverse drug reaction*) OR (drug delivery*) OR (drug hypersensitivity) OR |

| Name of Database/Filters | Query String |
|---|---|
| | PDSS OR (“Pharmacy Decision Support System”))<br>OR<br>((MH "Prescriptive Authority") OR (MH "Prescribing Patterns") OR (MH "Clinical Pharmacy Information Systems") OR (MH "Clinical Information Systems") OR (MH "Clinical Laboratory Information Systems") OR (MH "Decision Support Systems, Clinical") OR (MH "Pharmacy Service") OR (MH "Pharmacy Administration") OR (MH "Insurance, Pharmaceutical Services") OR (MH "Health Care Delivery, Integrated") OR (MH "Nursing Care Delivery Systems") OR (MH "Drug Delivery Systems"))<br>) |
| **Cochrane Central Register of Controlled Trials**<br><br>Year: 1996 - 2013 | (<br>(“Patient Identification System*” or CDSS or “Decision Support Systems Clinical” or “Decision Support Technique*” or “Decision Support Systems Management” or “health record* personal” or “personal health record*” or “Electronic Health Record*” or EHR* or “electronic health record*” or “electronic health information” or “electronic medical record*” or EMR* or “EHR implementation” or “Medical Order Entry System*” or “computerized physician order entry system*” or “computerized patient order entry system*” or CPOE* or “Patient Order Entry System*” or POE* or “Medical Records Systems Computerized” or “health information technolog*” or “hospital information system*” or “hospital information system*” OR “electronic information system*”)<br>OR<br>(health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic patient record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*" OR “cmar*”)<br>)<br>AND<br>(<br>(“Cost-saving*” or “cost effectiveness” or “cost effectiveness analysis” or “cost benefit*”* or "Cost-Benefit Analysis" or "cost benefit analysis" or “hospital cost*” OR "Quality of Health Care" or "Quality Assurance Health Care" or "Outcome Assessment" or "improved patient outcome*" or "patient outcome*" or "Health Care Evaluation Mechanism*" or "Data Collection" or "Health Expenditure*" or "healthcare expenditure*" or "health care expenditure*" or "healthcare cost*" or "health care cost*" or "health |

| Name of Database/Filters | Query String |
|---|---|
| | care quality improvement" or "health care quality improvement" or "quality of healthcare" or "quality of health care" or "Health Care Quality Access Evaluation" or "Health Care Cost*")<br>OR<br>(“Evidence-Based Practice” or “Evidence-Based Medicine” or EBM or ”evidence based practice” or “evidence based medicine” or “evidence-based practice” or “evidence-based practice” or “healthcare guideline*” or “health care guideline*” OR “practice guideline*”)<br>OR<br>("Electronic Prescribing" or "Clinical Pharmacy Information Systems" or “clinical patient order entry” or “hospital order entry system” or “electronic prescription*” or “electronic prescribing” or “e-prescription*” or “e-prescribing” or “automated medication system*” or “clinical pharmacy information system*” or “computerized prescribing” or “computerized prescription*” or “drug monitoring” or “adverse drug event*” or “medication error*” or “drug delivery system*” or “computerized physician entry order system*” or PDSS OR “Pharmacy Decision Support System” or “drug administration” or “drug delivery*” or “drug hypersensitivity*” or "computer-aided therap*”)<br>) |
| **PubMed**<br>Publication Date: 1/1/96 – 3/31/13<br>Species: Human<br>Reference Type:<br>Text Availability: | (<br>("Patient Identification Systems"[Majr]) OR CDSS OR ("Decision Support Systems, Clinical"[Mesh]) OR (“Decision Support Techniques”[Mesh] OR “Decision Support Systems, Management”[Mesh])OR ("Electronic Health Records"[Majr] OR EHR* OR electronic health record* OR electronic health information OR electronic medical record* OR EMR* OR EHR implementation) OR (“Medical Order Entry Systems”[Mesh] OR "Medical Records Systems, Computerized"[Majr] OR health information technolog* OR hospital information system*) OR (decision support OR health care decision support OR healthcare decision support) OR (“Picture Archiving Communication System*” OR PACS)<br>OR<br>(health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic patient record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*" OR cmar) |

| Name of Database/Filters | Query String |
|---|---|
| | )<br>AND<br>(<br>(("Cost-Benefit Analysis"[Majr]) OR cost benefit analysis OR "Quality of Health Care"[Majr]) OR ("Quality Assurance, Health Care"[Majr]) OR ("Outcome Assessment (Health Care)"[Majr]) OR (improved patient outcome* OR patient outcome*) OR ("Health Care Evaluation Mechanisms"[Majr]) OR ("Data Collection"[Mesh]) OR ("Health Expenditures"[Majr] OR healthcare expenditure* OR health care expenditure* OR healthcare cost* OR health care cost* OR hospital cost*) OR (healthcare quality improvement OR health care quality improvement OR quality of healthcare OR quality of health care OR "Health Care Quality, Access, and Evaluation"[Majr] OR "Health Care Costs"[Majr] OR "Cost Savings"[Mesh] OR cost benefit*))<br>OR<br>(("Evidence-Based Practice"[Majr]) OR "Evidence-Based Medicine"[Majr] OR EBM OR evidence-based medicine OR evidence based practice OR evidence-based practice OR healthcare guideline* OR health care guideline* OR standard of care* OR hospital guideline* OR practice guideline* OR standardized guideline*))<br>OR<br>("Electronic Prescribing"[Majr]) OR "Clinical Pharmacy Information Systems"[Mesh] OR electronic prescription* OR electronic prescribing OR e-prescription* OR e-prescribing OR medication system* OR clinical pharmacy information system* OR pdss OR ("Pharmacy Decision Support System") OR computerized prescribing OR computerized prescription* OR drug monitoring OR adverse drug event* OR medication error* OR "computerized physician order entry system*" OR "computerized patient order entry system*" OR cpoe)<br>) |
| **SCOPUS** | (<br>("Electronic Health Record*" OR ehr* OR electronic health information OR electronic medical record* OR electronic health care record* OR emr* OR ehr implementation OR "Patient Identification System*" OR cdss OR "Clinical Decision Support System*" OR "Decision Support Technique*" OR "Decision Support Systems Management" OR "Medical Order Entry System*" OR "Medical Records System*" OR health information technolog* OR hospital information system* OR decision support OR health care decision support OR healthcare decision support OR health information exchange OR hie OR electronic health data OR personal health data OR personal health record* OR health records personal OR ehealth OR e-health OR e-health OR medical records system* OR medical records system computerized OR computerized patient medical record* OR automated medical record* system* OR computerized medical record* OR |

| Name of Database/Filters | Query String |
|---|---|
| | computerized patient record* OR computerized patient medical record*)<br>OR<br>(health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic health record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*")<br>)<br>AND<br>(<br>("Cost-Benefit Analysis" OR cost benefit analysis OR cost-benefit analysis OR hospital cost* OR "Quality of Health Care" OR "Outcome Assessment" OR "Health Care Evaluation Mechanisms" OR "Health Expenditures" OR healthcare expenditure* OR health care expenditure* OR healthcare cost* OR health care cost* OR healthcare quality improvement OR health care quality improvement OR quality of healthcare OR quality of health care OR "Health Care Quality Access, and Evaluation" OR "Cost Savings" OR cost benefit*)<br>OR<br>("Evidence-Based Practice" OR "Evidence-Based Medicine" OR ebm OR evidence-based medicine OR evidence based practice OR evidence-based practice OR healthcare guideline* OR health care guideline* OR standard of care* OR hospital guideline* OR practice guideline* OR standardized guideline*)<br>OR<br>("Electronic Prescribing" OR "Clinical Pharmacy Information System*" OR "electronic prescription*" OR "electronic prescribing" OR "e-prescription*" OR "e-prescribing" OR clinical pharmacy information system* OR medication system* OR "patient order entry system*" OR cpoe OR poe OR clinical drug delivery OR drug monitoring OR decision support systems, clinical) OR (adverse drug reaction reporting systems OR databases, factual OR drug interactions OR drug monitoring) OR (computerized prescription* OR computerized prescribing OR "clinical pharmacy information system*" OR "medical order entry system*" OR electronic prescription* OR electronic prescribing OR electronic medication management OR drug-allergy OR drug-drug OR formulary decision support OR drug administration OR drug |

| Name of Database/Filters | Query String |
|---|---|
| | information OR pharmaceutical preparation* OR drug therapy, computer-assisted OR medication error* OR medication systems, hospital OR adverse drug event* OR prescribing error OR prescription error* OR patient order entry system* OR patient identification system*)<br>)<br>AND PUBYEAR > 1995 |

The search strings as developed by our research librarian for each of the databases are included under Appendix A.

We first used RefWorks to import selected references into the database which ended up being problematic as each iteration of running the search terms takes several hours because of the limitations of the import process. To address these limitations of RefWorks, a C# application was written to import references directly into a SQL database from the identified databases. The next section further details the refinements made to implement the fourth step.

**Initial meta-analysis reference import process**

In conducting a meta-analysis of the relationship between EHRs and HIEs with the effectiveness of care, the use of evidence-based treatment practices, and the use of e-prescribing, step 1involved the importing of relevant references from SCOPUS, PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Cochrane Central Register of Controlled Trials into RefWorks. This process turned out to be very labor-intensive, due to limitations on the parts of several of the web sites involved, mostly the limit on the number of references that can be imported or exported.

**Revised meta-analysis reference import process**

After the problems encountered with the initial reference import process, a streamlined process was implemented. This process utilized a relational SQL Server database to hold detailed reference data. Given the difficulties encountered with RefWorks, the original plan to populate this database using files exported from RefWorks was abandoned. Instead, a C# application was written by a programmer to import references directly into the database from the following raw data sources:

- PubMed: MEDLINE text file
- SCOPUS: ASCII text file
- CINAHL/Ebsco: XML file
- Cochrane Library: Text file

A refinement of the search terms used during the PubMed search greatly reduced the number of references returned. The following reference types were captured from PubMed: Clinical Trial; Clinical Trial, Phase I; Clinical Trial, Phase II; Clinical Trial, Phase III; Clinical Trial, Phase IV; Comparative Study; English Abstract; Evaluation Study; Guideline; Multicenter Study; Practice Guideline; and Validation Study.

For the Cochrane Library, the list of reference types was expanded to include the following: Cochrane Reviews: All Reviews; Economic Evaluations; Technology Assessments; and Trials.

**Creating the codebook**

A codebook in the context of the meta-analysis is a tool to extract relevant data that is reported in the original article/report. The primary purpose of the codebook is to assist in the collection of relevant data from each study that is relevant to the meta-analysis. Primary coding domains are, characteristics of the source of information,

participant attributes, methodological features, intervention details, and data related with effect size calculation. We started our codebook with section headings that are listed in the checklist recommended in the Cochrane Handbook (Higgins and Decks, 2008).

First and foremost only data that is relevant to the question being answered is extracted into the codebook. Second, the codebook is a record of the decisions that were made during the extraction of the data from the primary report though out the review process. Third, the coded data ultimately feeds into the analysis. Higgins and Decks (2008) in the Cochrane Handbook for Systematic Reviews of Interventions state, "Given the important functions of data collection forms, ample time and thought should be invested in their design (pg. 164)."

The first list variables of interest were identified based on the knowledge of the field, and the likely demographics and other explanatory variable that would be of use to a meta-analysis. This list was created under the domains identified above. Under each of the domains sub-domains were created to provide structure and flexibility for the coder. For example, the outcomes were divided into patient and system and further each reported measure was characterized as being a structure, process, or an outcome measure. Additionally, we aimed for granularity (*i.e*. more detail whenever possible) in coding, for example, clinical decision support systems can be to account/address solutions related with laboratories or e-prescribing, and in turn can trigger a response by triggering alerts, notifications, reminders. We erred on the side of more granularity than less because aggregating things up is easier while going to specifics is somewhat difficult.

We quickly learned that all abstracts are not the same as they relate to information needed for meta-analysis. Structured abstracts contain higher level of *codable*

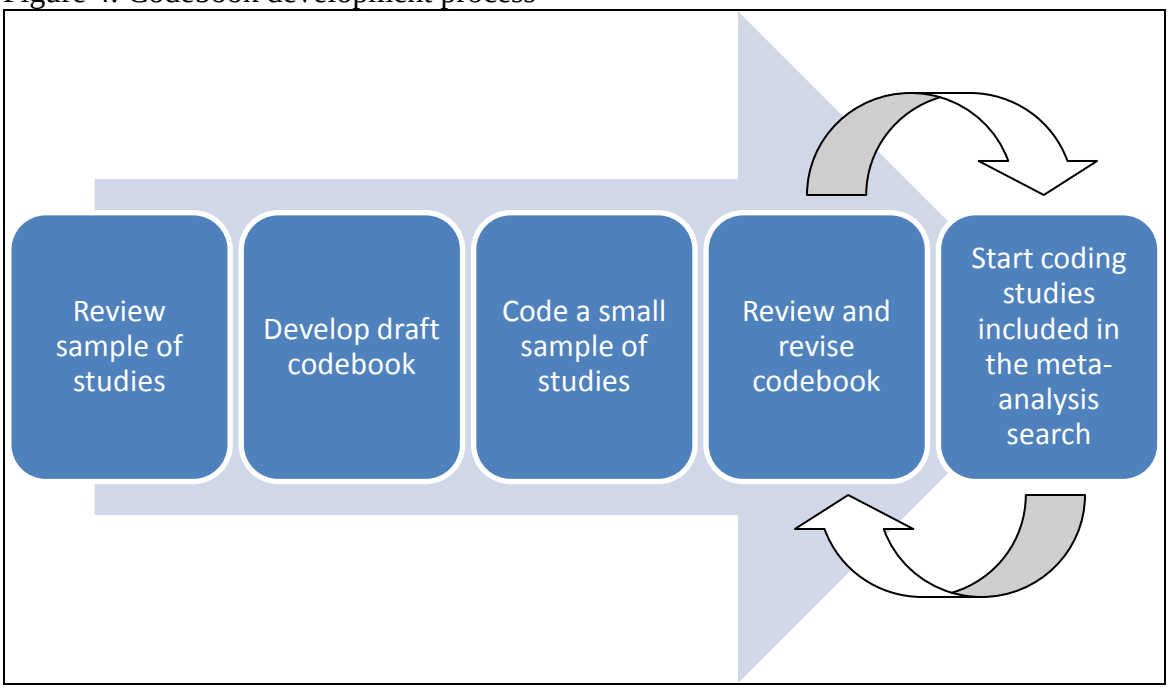
information than narrative or descriptive abstracts. We believe that the codebook and the translated data forms should allow for additions to the coding scheme as there is always a possibility of a new outcome being studied that was not evident in the beginning.

The final codebook was created by coding the first 25 articles and adding categories for information that was available in the article but for which there were no categories in the codebook. Once an entire article could be coded without any additions needed to the codebook categories we finalized the codebook for use in the proposed meta-analysis. The first 25 studies were coded using a paper-based form.

**The Iterative Process**

The codebook development process is an iterative process and we followed the guidance that was issued by the presenters at the meta-analysis summer institute at the University of Missouri (refer Fig 4). The codebook development process starts with a reviewing a sample of the literature, followed by a draft of the codebook, which is then used to code a small sample of studies, add data elements to the codebook that were missing in the first draft, revise the codebook. The last two steps continue until all studies that are included can be coded completely without any additions being needed to the codebook.

Figure 4: Codebook development process




**Formatting the codebook**

The codebook was created with two primary purposes in mind, the ease of coding and the usefulness of the data that was being captured. After reviewing some codebooks that were available to the author it was clear that following the usual flow of the article would make it easier to code an article. Consequently, we created the following headings under which to code the information, refer to Table 3.

Table 3: Sections of the codebook

| | |
|---|---|
| **Study characteristics** | This section captured the information about when the study was done; where the study was done; the setting in which the study was done; descriptors of the study setting; like size of practice/hospital; number of physicians and other allied health practitioners; and how was the study funded. The sub-domains under this category are study identifiers and study setting. |
| **Eligibility** | Confirms eligibility for inclusion and records the reason for exclusion. |
| **Methods** | This section was pretty typical of the usual research format, type of study design used, study duration, sequence generation, allocation sequence |

| | |
|---|---|
| | concealment, blinding, and any other concerns about bias. |
| **Participants** | This section was a challenging to develop when it came to participant characteristics. Typically, in research studies we define the population/sample that is being studies, the first point this differs is that we have patients that are impacted, but sometimes it is the physicians' behavior that is impacted and then we are studying the result of the physician behavior change on the patient. Consequently, we created a section where we capture the practitioner characteristics, followed by patient characteristics<br><br>Information on physician/healthcare provider and patient characteristics, (*i.e.*, total number, setting, diagnostic criteria, age, sex, country, co-morbidity, socio-demographic (race, ethnicity, household income, education, insurance type), and year the data were collected.) |
| **Interventions** | The details about the intervention: people who delivered the intervention and people to whom the intervention was delivered; what part of the treatment process is the intervention being delivered; type of specialist that is delivering/conducting the intervention; years of experience of the specialist since finishing their education; and details about the EHRs and CDSS. |
| **Outcomes** | This section is focused on the clear identification of outcomes and their operational definitions; frequency and time-points of collection, unit of measurement, IOM domains targeted for quality, information on standardized tools, scoring details, and other relevant instrumentation information. |
| **Results** | The Results section was organized by capturing relevant pieces of data reported for experimental/control group such as sample size, mean, standard deviations, standard error, effect size, hypothesized effect size, mean difference between the compared groups, test values (*e.g.* Chi square, t-test, f-test, logistic regression variable, correlation, degrees of freedom, odds ratio, inter-rater reliability), and any other relevant study characteristics that may be of significance. In addition, any other biases that may have impact on how study findings should be interpreted are included here |
| **Miscellaneous** | This section can be used for any over general coder observations, key conclusions of the study authors, etc. |

# Chapter 3 - Results

## Importing articles using RefWorks

SCOPUS was the first data source imported into RefWorks. The SCOPUS search query, which was filtered to only include references published between 1996 and 2013, yielded 1,036 references. SCOPUS searches do not allow for filtering out references with no abstracts available. These 1,036 references were exported into a Research Information Systems (RIS) file.

Due to the small number of references, SCOPUS was able to export them all into a single RIS file; SCOPUS allows up to 2,000 references to be exported at a time. In addition, RefWorks' import limit of 2000 references didn't apply; all 1,036 references were imported into RefWorks in a single batch. Using RefWorks' 'exact match' de-duplication feature, which matches references based on title, author(s), and publication year, yielded a final set of 988 unduplicated references.

Next, references from PubMed were imported. The PubMed search used the following filters:

- Publication Date: 1/1/1996 – 3/31/2013
- Species: Human only
- Text Availability: Abstract Available
- Reference Type: Comparative Study, English Abstract, Evaluation Studies, Guideline, Meta-Analysis, Multicenter Study, Practice Guideline, Review, Systematic Reviews, Validation Studies

The PubMed query yielded 132,151 references. Due to RefWorks' ability to only import 2,000 references at a time, these references had to be exported to 100 separate MEDLINE files, which were split by publication date ranges. These files were then

imported into RefWorks. RefWorks imports of larger batches of references frequently failed and had to be re-run.

Strangely, once all 100 files were imported into RefWorks, a total of 156,132 references existed in the RefWorks folder assigned to PubMed references. The only possible explanation is that some references ended up in multiple PubMed MEDLINE export files, although the publication date filters would seem to preclude this occurring. RefWorks' 'exact match' de-duplication process yielded a final total of 131,366 unduplicated PubMed references.

Next, references from CINAHL were imported. The CINAHL search used the following filters:

- Publication Date: January 1996 – March 2013
- Abstract Available

The CINAHL search yielded 6,098 references. To export CINAHL references, they must first be placed in a folder. Four folders containing 1,500 references and one folder containing 98 references were created and populated with references. The EBSCOhost environment that houses the CINAHL database only allows for the movement of 50 references at a time to a folder, so populating the five folders was a labor-intensive process.

After populating the folders, the references in the folders were exported to EndNote's free Basic web site. A test of EBSCOhost's direct export functionality to RefWorks revealed that it took an uncharacteristically long time to export a batch of 50 references at a time to RefWorks. Time was saved by first exporting to EndNote, then exporting batches of 1,500 references at a time from EndNote to RefWorks. RefWorks' 'exact match' de-duplication process yielded a total of 6,082 unduplicated references.

Finally, references from the Cochrane Central Register of Controlled Trials were imported. Cochrane does not allow for filtering based on publication date. The Cochrane search yielded 789 references; these were exported into a 'PC Citation and Abstract' text file, which was then imported into RefWorks. RefWorks' 'exact match' de-duplication process yielded no duplicate references.

After importing these references, RefWorks' 'exact match' de-duplication tool was used to eliminate redundant references across the four sources. When this tool finds duplicate references, it flags the most recently added reference for removal. This sequencing means that the de-duplication process would not remove SCOPUS references.

The cross-source de-duplication process contained the following stages:

- 988 SCOPUS references and 131,366 PubMed references yielded 132,155 unduplicated references.
- 132,155 unduplicated SCOPUS/PubMed references and 6,082 unduplicated CINAHL references yielded 137,737 unduplicated references.
- 137,737 unduplicated SCOPUS/PubMed/CINAHL references and 789 Cochrane Library references yielded 138, 526 unduplicated references (no duplicates were found between Cochrane and the other sources).

### Limitations of RefWorks

Importing large volumes of references into RefWorks is a highly labor-intensive process, due to RefWorks' import limit of 2,000 references per batch. RefWorks' import process is slow; an import of 1,500 references can often take 2-3 minutes. Often, RefWorks does not properly inform the user when a batch import has completed, leading the user to believe that the import process has hung. In addition, imports of large batches of references often fail.

In revising our search strategies after importing many references into RefWorks, we ended up with many references that required deletion. Deletion of large numbers of

references from RefWorks, however, is extremely slow and frequently fails. Problems with deleting references imported from prior searches meant that, to de-duplicate references from the most recent search, they had to be moved manually into the same folder so that de-duplication could be run on that individual folder. Moving references between folders yields great potential for errors; RefWorks provides no 'undo' functionality.

For these reasons, RefWorks is not considered an ideal tool for collating large volumes of references from multiple sources.

**Import process using the C# application**

The counts of references imported from the four sources were as follows:

- SCOPUS: 565 references (550 with abstracts)
- PubMed: 41,426 references (all with abstracts)
- CINAHL: 5,579 references (all with abstracts)
- Cochrane Library: 1,750 references (752 with abstracts)

The PubMed 'exact match' de-duplication logic was re-created for the SQL Server database. This logic considers references to be duplicates if they have the same title, publication year, and authors. Each individual source was checked for duplicate references; subsequently, checks were performed to see if references were duplicated across sources. Unlike RefWorks' de-duplication process, the SQL de-duplication did not result in the physical deletion of references from the database. Instead, an associative table flags duplicate records, which remain intact in the database. Using this technique, any filtering process performed on the references can be tracked and re-created, without references being physically deleted.

De-duplication of references within each source having abstracts yielded the following reference counts:

- SCOPUS: 549 unduplicated references
- PubMed: 41,415 unduplicated references
- CINAHL: 5,5364 unduplicated references
- Cochrane Library: 752 unduplicated references (no duplicates found)

The de-duplicated references within each source were then compared. These comparisons yielded the following counts of unduplicated references:

- SCOPUS and PubMed: 41,961 unduplicated references
- SCOPUS/PubMed and CINAHL: 46,916 unduplicated references
- SCOPUS/PubMed/CINAHL and Cochrane Library: 47,364 unduplicated references

The efficiency of the C# application over RefWorks is undeniable, not just in terms of the time it takes to run and import the results from the query but the sheer number of times that steps have to be repeated because of the repeated crashing of the RefWorks application. Table 4 summarizes the comparison of the two processes.

Table 4: Comparison of results retrieved by C# application and RefWorks

| **Database** | **RefWorks** | | **C# application** | |
|---|---|---|---|---|
| | Total imports | No. after removing exact matches | Total imports | No. after removing exact matches |
| SCOPUS | 1,036 | 988 | 565 | 549 |
| PubMed | 132,151 (156,132) | 131,366 | 41,426 | 41,415 |
| CINAHL | 6,098 | 6082 | 5,379 | 5,364 |
| Cochrane | 789 | 789 | 1,750 | 752 |

**Search String results**

We used the search strings listed in Chapter 2 to download the articles for the first level of review based on the title and the level of information available about EHR use and the outcomes reported at the patient and/or system level. There were almost as many journal articles ad review articles. We summarize the distribution of the studies selected by the type of reference it was coded under in Table 5.

Table 5: Counts of references by reference types

| Reference Type | Total | | With Abstract | |
|---|---|---|---|---|
| | Count | % | Count | % |
| Article | 657 | 0.9% | 644 | 0.9% |
| Clinical trial | 2 | 0.0% | 2 | 0.0% |
| Cochrane review | 789 | 1.0% | 789 | 1.0% |
| Conference paper | 57 | 0.1% | 55 | 0.1% |
| Congresses | 4 | 0.0% | 4 | 0.0% |
| Doctoral dissertation | 95 | 0.1% | 95 | 0.1% |
| Economic evaluation | 986 | 1.3% | 0 | 0.0% |
| Editorial | 16 | 0.0% | 11 | 0.0% |
| English abstract | 21 | 0.0% | 21 | 0.0% |
| Evaluation studies | 4 | 0.0% | 4 | 0.0% |
| Guideline | 4 | 0.0% | 4 | 0.0% |
| Historical article | 1 | 0.0% | 1 | 0.0% |
| Introductory journal article | 3 | 0.0% | 3 | 0.0% |
| Journal article | 22501 | 29.3% | 22501 | 29.7% |
| Lectures | 9 | 0.0% | 9 | 0.0% |
| Letter | 12 | 0.0% | 11 | 0.0% |
| Masters thesis | 4 | 0.0% | 4 | 0.0% |
| Meta-analysis | 255 | 0.3% | 255 | 0.3% |
| Multicenter study | 1059 | 1.4% | 1059 | 1.4% |
| News | 1 | 0.0% | 1 | 0.0% |
| Newspaper article | 1 | 0.0% | 0 | 0.0% |
| Note | 7 | 0.0% | 3 | 0.0% |
| Other review | 65 | 0.1% | 0 | 0.0% |
| Portraits | 1 | 0.0% | 1 | 0.0% |
| Practice guideline | 240 | 0.3% | 238 | 0.3% |
| Randomized controlled trial | 2969 | 3.9% | 2969 | 3.9% |

| Reference Type | Total | | With Abstract | |
|---|---|---|---|---|
| Research support, NIH, extramural | 1386 | 1.8% | 1386 | 1.8% |
| Research support, NIH intramural | 73 | 0.1% | 73 | 0.1% |
| Research support, non-US. Govt. | 17243 | 22.4% | 17243 | 22.8% |
| Research support, US. Govt., non-PHS. | 1047 | 1.4% | 1047 | 1.4% |
| Research support, US. Govt., PHS | 2621 | 3.4% | 2621 | 3.5% |
| Retracted publication | 13 | 0.0% | 13 | 0.0% |
| Review | 21282 | 27.7% | 21267 | 28.1% |
| Short survey | 3 | 0.0% | 2 | 0.0% |
| Technical report | 2 | 0.0% | 2 | 0.0% |
| Technology assessment | 20 | 0.0% | 0 | 0.0% |
| Trial | 903 | 1.2% | 893 | 1.2% |
| Twin study | 8 | 0.0% | 8 | 0.0% |
| Validation studies | 2457 | 3.2% | 2457 | 3.2% |
| Video-audio media | 10 | 0.0% | 10 | 0.0% |
| Webcasts | 3 | 0.0% | 3 | 0.0% |
| No reference type specified | 21 | 0.0% | 21 | 0.0% |
| **TOTAL** | **76855** | | **75730** | |

**PRISMA Flowchart**

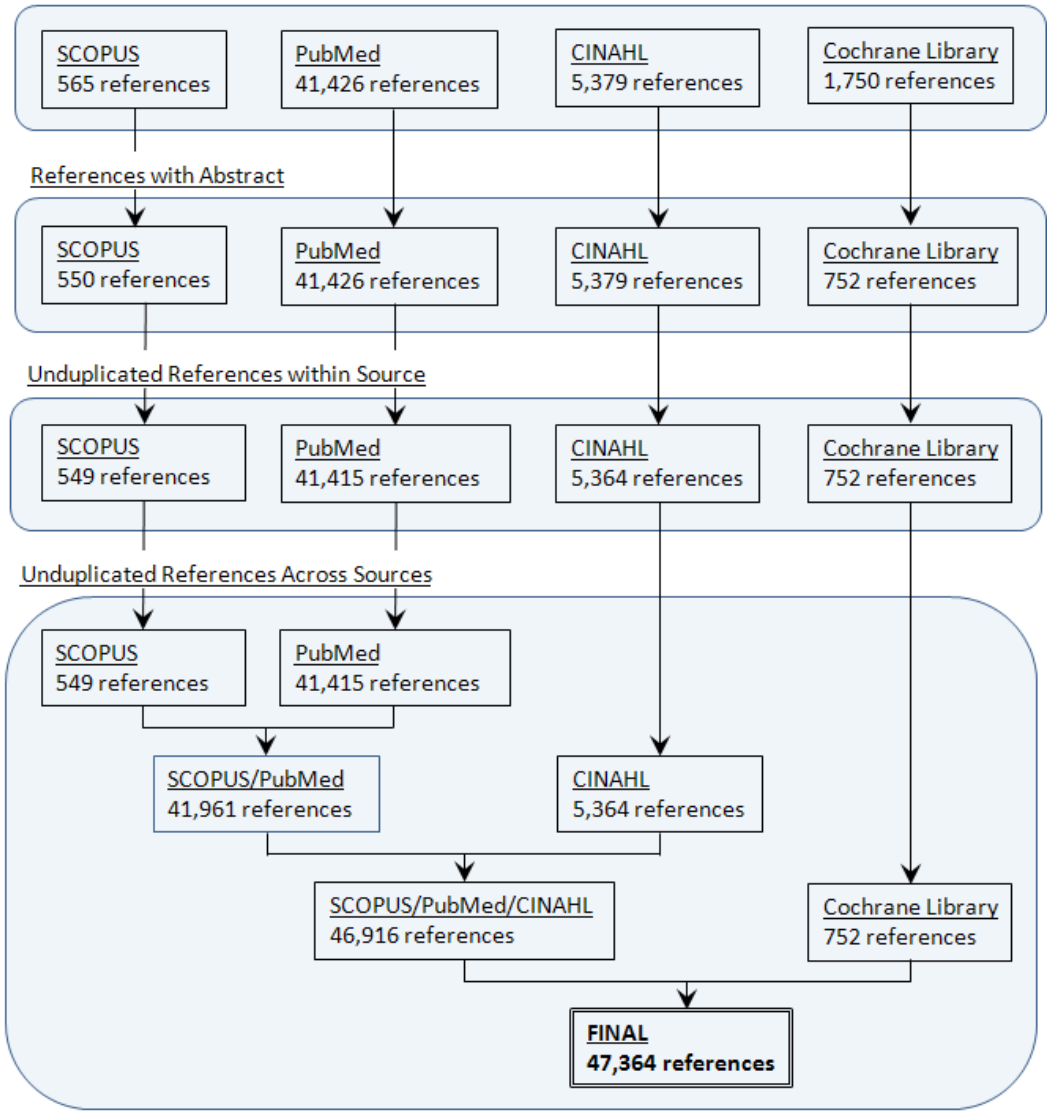
References were de-duplicated using RefWorks' 'Exact Duplicate' functionality, which matches references based on Author Name(s), Title, and Year of Publication. This de-duplication process yielded a total of 47,364 references and the flow is depicted in Figure 5.

Counts include the following reference types: Article; Clinical Trial; Clinical Trial, Phase I; Clinical Trial, Phase II; Clinical Trial, Phase III; Clinical Trial, Phase IV; Comparative Study; Conference Paper; Congress; Controlled Clinical Trial; Doctoral Dissertation; Economic Evaluation; English Abstract; Evaluation Study; Guideline; Historical Article; Introductory Journal Article; Journal Article; Lecture; Masters Thesis; Multicenter Study; Portrait; Practice Guideline; Randomized Controlled Trial; Research Support, N.I.H., Extramural; Research Support, N.I.H., Intramural; Research Support,

Non-U.S. Government; Research Support, U.S. Government, Non-P.H.S.; Research Support, U.S. Government, P.H.S.; Short Survey; Technical Report; Technology Assessment; Trial; Twin Study; Validation Study

This search excludes references with the following terms in either the title or the abstract: Bibliometric Analysis; Bibliometric Analysis and Review; Comprehensive Review; Critical Review of Literature; Editorial; Evidence from Panel Data; Expert Opinion; Inventory of Tools and Techniques; Literature Review; Meta-Analysis; Methods Studies; Methods Study; Narrative Literature Review; Narrative Review; Perception Studies; Qualitative, Review of Literature; Review the Literature; Reviewed the Literature; Satisfaction; Study of the Literature; Systematic Review; Technology Assessment; Workshop Report. This search also excludes references with the following terms in the title: Overview; Perception; Protocol; Reflections; and Study Design.

Figure 5: Data sources for meta-analysis: EHRs' and HIEs' Impact on cost-effectiveness of care, use of evidence-based practices, and E-prescribing




The Codebook

The next section presents the final codebook that was used by the author to code the articles for meta-analysis (refer Table 6). A columnar format was created with the headings of variable name, coding scheme, and instructions. We used a paper version of the codebook to code the first 25 SCOPUS articles.

Table 6: Meta-analysis Codebook

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| *I. Study Characteristics* | | |
| **Study Identifiers** | | |
| Study Number | 1- | This is the number that uniquely identifies a study that is being coded. We will use the PubMed/Scopus # |
| Comparison sample number | Study Number.comparison number | Some studies have multiple comparisons, e.g. two or more treatment groups compared to the same control group. Each group comparison is coded multiple times |
| Reviewer ID | | Identifier for the coder |
| Citations and Contact details | | |
| Source of Information | 1 = Journal<br>2 = unpublished report<br>3 = dissertation<br>4 = book/chapter<br>5 = presentation<br>9 = other | |
| Study Purpose | | |
| Year of publication | YYYY | Year the report appears in print.<br>If there are multiple reports on the same study, use the year which will be used to calculate the outcome effect size |
| Funding | 1 = Federal Agency<br>2 = State Agency<br>3 = Local Agency<br>4 = Foundation<br>5 = University supported<br>0 = No source listed | Code source of funding and support for the study |
| Funding Detail | 1 = AHRQ | |
| Conflict of Interest | 0 = No conflict of interest reported<br>1 = Yes, conflict of interest reported<br>2 = Yes, disclosure forms provided<br>9 = No mention of COI | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| **Study Setting** | | |
| Country | 0= Not reported<br>1 = US<br>2 = Canada<br>3 = Europe<br>4 = Australia<br>5 = New Zealand<br>6 = UK<br>7 = Germany<br>8 = Taiwan<br>9 = Multi-country | Code the country where the study was conducted |
| Population density | 0 = Not reported<br>1 = Urban<br>2 = semi-urban/sub-urban<br>3 = rural | |
| Healthcare setting | 0 = Not reported<br>1 = hospital<br>2 = ambulatory | |
| Practice Setting | 0 = not reported<br>1 = single specialty<br>2 = multispecialty | |
| Specific setting | 0 = not reported<br>1 = Emergency Department<br>2 = Inpatient<br>3 = Outpatient<br>4= Inpatient & Outpatient<br>5 = Long-term care<br>6 = Nursing Home<br>7 = Intensive Care Unit<br>8 = geriatric ward | |
| Institution Type General Setting | 0 = Not reported<br>1 = Academic/Teaching/University-based<br>2 = Kaiser<br>3 = Harvard Pilgrim<br>4 = Wellpointe | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 5 = Regenstrief Institute<br>6 = Veterans Administration<br>7 = Partners Health Care<br>8 = Brigham and Women's Hospital<br>9 = LDS Hospital/Intermountain Health Care<br>10 = Other | |
| Institutional Status | 0 = Not reported<br>1 = For profit<br>2 = Not for profit | |
| Size of Hospital | | No. of beds<br>No. of doctors<br>No. of pharmacists |
| Safety Net/FQHC | 0 = no<br>1 = yes | |
| Size of Practice | 0 = not reported<br>1 = solo<br>2 = PCP, Small Physician Practice (2-9 physicians)<br>3 = PCP, Large group Practice (consisting of 10-49 physicians)<br>4 = PCP, Large group Practice (50 or more physicians)<br>9 = not applicable | |
| Payer Mix in % | 0= not reported<br>1 = Medicare<br>2 = Medicaid<br>3 = Private insurance<br>4 = Uninsured | |
| *II. Eligibility Methods* | | |
| Reason for Exclusion | 1 = insufficient data on results<br>2 = no intervention (no EHR or HIT mentioned)<br>3 = concerns about bias<br>4 = language (abstract available in English, not sufficient data to code) | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 5 = other (specify) | |
| *III. Methods* | | |
| Theoretical Constructs | | |
| Study Design | 1 = Randomized Control Trial (RCT)<br>2 = Controlled Clinical Trial<br>3 = Time-series<br>4 = Pre-post<br>5 = Case-control<br>6 = Cohort<br>7 = Case-series<br>8 = Cohort study with historical control<br>9 = Time-motion<br>10 = Cross-sectional<br>11 = Retrospective<br>12 = observational<br>13 = process-based<br>14 = survey | Case-series: A study reporting observations on a series of individuals, usually all receiving the same **intervention**, with no **control group**. (CC)<br><br>Case-control study: A study that compares people with a specific disease or **outcome** of interest (cases) to people from the same **population** without that disease or outcome (**controls**), and which seeks to find associations between the outcome and prior exposure to particular risk factors. This design is particularly useful where the outcome is rare and past exposure can be reliably measured. Case-control studies are usually **retrospective**, but not always. (CC)<br><br>Cluster randomised trial: A trial in which clusters of individuals (e.g. clinics, families, geographical areas), rather than individuals themselves, are randomised to different **arms**. In such studies, care should be taken to avoid **unit of analysis errors**.<br><br>Controlled (clinical) trial (CCT): This is an indexing term used in **MEDLINE** and **CENTRAL**. Within CENTRAL it refers to trials using quasi-randomisation, or trials where double blinding was used but **randomisation** was not mentioned.<br><br>Cohort study: An **observational study** in which a defined group of people (the cohort) is followed over time. The **outcomes** of people in subsets of this cohort are compared, to examine people who were exposed or not exposed (or exposed at different levels) to a particular **intervention** or other factor of interest. A |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | | **prospective** cohort study assembles **participants** and follows them into the future. A **retrospective** (or historical) cohort study identifies subjects from past records and follows them from the time of those records to the present. Because subjects are not allocated by the investigator to different interventions or other exposures, **adjusted analysis** is usually required to minimise the influence of other factors (**confounders**). Controlled before and after study: A **non-randomised study** design where a control **population** of similar characteristics and performance as the **intervention group** is identified. Data are collected before and after the **intervention** in both the **control** and intervention groups.<br><br>Randomised controlled trial: An experiment in which two or more interventions, possibly including a control intervention or no intervention, are compared by being randomly allocated to participants. In most trials one intervention is assigned to each individual but sometimes assignment is to defined groups of individuals (for example, in a household) or interventions are assigned within individuals (for example, in different orders or to different parts of the body) |
| No. of sites | | No. of practices where study was tested |
| Data Collection Year | | |
| Data Collection (Time period) | ___in years<br>___In months<br>___In weeks<br>___In days | |
| Medium of data collection | 0 = not reported<br>1 = EHR<br>2 = eRx | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 3 = eLIS<br>4 = paper/data coding<br>5 = video tape<br>6 = transcriptions | |
| IRB reported | 0 = no<br>1 = yes | |
| Inter-rater reliability reported | 0 = no<br>1 = yes | |
| Inter-rater value reported | | |
| Operational definitions | 0 = no<br>1 = yes | |
| Analytic tools used | Atlast ti<br>Epidata<br>R<br>SPSS<br>SAS<br>STATA | |
| *IV. Participants* | | |
| **Physician/Health Care Provider Characteristics** | | |
| Intervention Group | 0 = None mentioned<br>1 = Physicians or DO<br>2 = Nurse Practitioner<br>3 = Physicians Assistant<br>4 = Pharmacists<br>5 = | |
| Specialty | 0 = None mentioned<br>1 = Internal Medicine<br>2 = Family Practice<br>3 = Pediatrics<br>4 = Surgery<br>5 = Anesthesia | |
| No. of women | | |
| No. of men | | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| Years since graduation Mean | | |
| Years since graduation SD | | |
| Mean Age of Sample | | |
| SD of age of sample | | |
| **Patient Demographics** | | |
| Total no. of patients | | |
| No. of women | | |
| No. of men | | |
| Ratio of Female:Male | | |
| Percent of women | 999 – not reported | |
| Percent Black | | |
| Percent White | | |
| Percent Hispanic/Latino | | |
| Percent Other | | |
| Age groups | 1 = young adult<br>2 = older adult<br>3= children | |
| Mean age in years | 999 – Not reported | For studies with a single Tx and control group, code the overall mean of the sample. If the study reports mean age separately for Tx and Control group. Calculate a mean from these separate means. |
| SD age of sample | | |
| Estimated Household income | | |
| Insurance type | 0= Not reported<br>1 = Medicare<br>2 = Medicaid<br>3 = Private insurance<br>4 = Uninsured | Is the primary insurance reported during the most recent doctor's visit |
| Mean Education of sample | 999 – Not reported | |
| Language | | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| *V. Interventions* | | |
| **IT/EHR System Descriptors** | | |
| Type of EHR | 1 = Complete EHR<br>2 = Modular EHR<br>3 = EHR (enterprise)<br>4 = EHR + CDS | |
| Certified EHR | 0 = no<br>1 = yes<br>9 = not reported<br>10 = not applicable | |
| Name of EHR | | |
| Year EHR implemented | | |
| CDSS | 0 = no<br>1 = yes<br>9 = not reported | |
| If yes, | 0 = Not mentioned<br>1 = Integrated with EHR<br>2 = Not integrated with EHR | |
| Type of CPOE and CDSS | e-prescribing<br>laboratory system<br>e-prescribing + CDSS<br>laboratory system + CDSS | |
| If yes, name of CDSS | | |
| CDSS Functionality | Alerts (low-level, intermediate-level, high-level)<br>Notifications<br>Reminders<br><br>For labs<br>Warnings<br>Alarms | |
| Type of alert | 0 = None mentioned<br>1 = drug contraindication<br>2 = drug-drug interaction | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 3 = dose-range checking | |
| Response to alert/notification/reminder | 0 = none reported<br>1 = heeding<br>2 = overriding<br><br>For lab messages<br>0 = none reported<br>1 = accepting<br>2 = ignoring | Heeding = where a prescription was altered or abandoned so that the alert no longer generated<br>Overriding = where the prescription proceeded to completion despite the alert |
| Point of intervention in Tx process | 0 = None mentioned<br>1 = admission<br>2 = during treatment<br>3 = follow-up<br>4 = discharge | |
| Staff Trained | 0 = no<br>1 = yes | |
| Duration of training | | |
| Type of training | 0= none mentioned<br>1 = self-paced web-based<br>2 = 1 on 1 training<br>3 = in-class group<br>4 = in-class role-based group | |
| CME provided | 0 = no<br>1 = yes | |
| *VI. Outcomes* | | |
| Level of Outcome | 1 = patient<br>2 = system<br>3 = other | |
| Type of measure | 1= structure<br>2= process<br>3 = outcome | |
| IOM Domain | 0 = Not Reported<br>1 = Effectiveness/Access<br>2 = Efficiency | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 3 = Equity<br>4 = Safety<br>5 = Timeliness<br>6 = Patient-centeredness | |
| Outcome being Evaluated | 1= Adherence<br>2 = Surveillance<br>3 = Adverse Drug events<br>4 = Medication Errors<br>5 = Utilization of Care<br>6 = Time utilization<br>7 = Guidelines based care (specify) | |
| Disease Focus | 0 = none reported<br>1 = Asthma<br>2 = Diabetes<br>3 = Hypertension/hypercholesterolemia<br>4 = Cardiovascular<br>5 = Behavioral Health<br>6 = Chronic Kidney Disease (CKD)<br>7 = Heart disease<br>8 = Kidney Dx<br>9 = Vascular events<br>10 = Venous thrombosis<br>11 = Hyperlipidemia | |
| | | |
| **Outcomes related with specific outcomes** | | |
| **e-Prescribing Outcomes** | | |
| Total no. of prescription reviewed | | |
| No. of erroneous prescription orders | | |
| No. of prescription errors | | |
| No. of physicians represented in the error | | |
| No. of patients | | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| represented in the errors | | |
| Mean erroneous order per patient | | |
| SD | | |
| Medication Errors | Prescribing Error<br><br>If prescribing error then | Duration error<br>Inappropriate abbreviation error<br>Strength error<br>Directions error<br>Frequency error<br>Amount error<br>Dose error<br>Route error<br>Refill error<br>Other errors |
| Specialty setting for erroneous medication orders | General Medicine<br>Cardiology<br>Elderly Care | |
| No. of oral formulations associated with the error | 0 = not reported<br>1= one oral formulation<br>2 = multiple oral formulation<br>3 = inhalation formulations | |
| Therapeutic categories | 0 = not reported<br>1 = antihypertensive classes<br>2 = analgesics and antirheumatics<br>3 = single & combined inhalation bronchodilators<br>4 = antibacterials and antifungals | BNF categories |
| Medications | 0 = not reported<br>1 = paracetamol<br>2 = salbutanol<br>3 = omeprazole<br>4 = aspirin<br>5 = codeine | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | 6 = Seretide®<br>7 = senna<br>8 = prednisolone | |
| Errors of Commission | | |
| Errors of Ommission | | |
| Ratio commission:Ommission | | |
| Error classifications | Minor error<br>Most erroneous | |
| **Diabetes** | | |
| Standard Type | 0 = no<br>1 = Yes - | |
| | **Care standards**<br>Receipt of a glycated hemoglobin value Y/N<br>Testing for urinary microalbumin or prescription of an angiotensin-converting – enzyme inhibitor or an angiotensin-receptor blocker Y/N<br>An eye examination to screen for diabetic retinopathy Y/N<br>Administration of pneumococcal vaccination Y/N<br><br>**Intermediate-outcome standard**<br>Glycated Hb value below 8% Y/N<br>A blood pressure below 140/80 mm Hg Y/N<br>A low-density lipoprotein (LDL) cholesterol value below 100 mg per deciliter or documented prescription for a statin medication Y/N<br>A body-mass index (BMI) below 30 Y/N<br>Smoking status Y/N | 9 Total no. of quality standards (4 standards of care + 5 standards of Intermediate outcomes) |
| | | |
| **Hyperlipidemia** | | |
| Lab data | Total Cholesterol Y/N | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| | Triglycerol Y/N<br>HDL-C (high-density lipoprotein cholesterol) Y/N<br>LDL-C (low-density lipoprotein cholesterol) Y/N | |
| | | |
| | | |
| **Asthma** | | |
| Fast acting beta agonists | 0 = no<br>1 = Yes | |
| | | |
| | | |
| **CKD Outcomes** | | |
| Referral to a nephrologists | 0 = no<br>1 = Yes | |
| Albuminuria/proteinuria assessments | 0 = no<br>1 = Yes | |
| CKD documentation | 0 = no<br>1 = Yes | |
| Optimal BP (130/80 mm Hg) | 0 = no<br>1 = Yes | |
| **Instrumentation** | | |
| Measurement/Instrumentation used | 0 = no<br>1 = yes | Code yes if a standardized measurement tool or scale was used. |
| Standardized instrument | 0 = no<br>1 = yes | |
| Name the instrument used to measure outcome | | |
| **If not on the above mentioned list, list specific outcomes being measured** | | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| *VII. Results* | | |
| **Experimental/Treatment Group (code for each outcome) – sample size, missing participants, 2 x 2 table for dichotomous data, means and standard deviations for continuous data)** | | |
| What is being compared | | |
| Total number of Tx Ss at baseline | | |
| Number of Tx Ss in data reported at baseline | | |
| Tx group baseline mean | | |
| Tx group baseline SD | | |
| Tx group baseline SE | | |
| Total number of Tx Ss at outcome | | |
| Number of Tx Ss in data reported at outcome | | |
| Tx group outcome mean | | |
| Tx group outcome SD | | |
| Tx group outcome SE | | |
| Control/Comparison Group | | |
| Total number of Co Ss at baseline | | |
| Number of Co Ss in data reported at baseline | | |
| Co group baseline mean | | |
| Co group baseline SD | | |
| Co group baseline SE | | |
| Total number of Co Ss at outcome | | |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| Number of Co Ss in data reported at outcome | | |
| Co group outcome mean | | |
| Co group outcome SD | | |
| Co group outcome SE | | |
| ***Direction of Effect Size*** | | |
| Effect in the hypothesized direction for Tx vs. Co? | 1 = Tx group outcome score better than control group outcome score<br>0 = Tx and Co group outcome scores are the same<br>-1 = Co group outcome score better than Tx group outcome score<br>999 = single group study that did not compare independent Tx and Co groups | |
| Effect in the hypothesized direction for Tx-outcome vs. Tx-baseline? | 1 = Tx group outcome score better than Tx group baseline score<br>0 = Tx outcome and baseline scores are the same<br>-1 = Tx group baseline outcome score better than Tx group outcome score<br>999 = if no baseline and outcome data to compare for the Tx group | |
| Effect in the hypothesized direction for Co-outcome vs. Co-baseline? | 1 = Co group outcome score better than Co group baseline score<br>0 = Co outcome and baseline scores are the same<br>-1 = Co group baseline outcome score better than Co group outcome score<br>999 = if no baseline and outcome data to compare for the Tx group | |
| **Mean difference or change score** | | |
| Mean Difference between Tx and Co | | Mean difference must NOT be percent difference, these must be absolute values. These must be reported in the |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| groups at posttest | | study, do NOT calculate these. |
| Mean Difference between Tx and Co groups at pretest | | Mean difference must NOT be percent difference, these must be absolute values. These must be reported in the study, do NOT calculate these. |
| Treatment group change score mean | This is the difference between baseline scores and outcome scores for the Tx group Ss. | Change scores must NOT be percent change, these must be absolute values.<br>These values must be reported in the study; do NOT calculate these. |
| Treatment group change score SD | | |
| Treatment group change score SE | | |
| Control group change score mean | | Change scores must NOT be percent change, these must be absolute values.<br>These values must be reported in the study; do NOT calculate these. |
| Control group change score SD | | You will only code this item if the study includes a control group of subjects independent from the treatment group of subjects. |
| Control group change score SE | | You will only code this item if the study includes a control group of subjects independent from the treatment group of subjects. |
| **t-statistic: information for Tx vs. Co group at outcome (post-intervention)** | | |
| t value – post-test comparison between treatment and control groups | | Be sure to use the t value that compares the means of the Tx versus the Co groups.<br>Do NOT use a t test that compares mean differences or change scores.<br>Do NOT use a paired t-test. |
| Degrees of freedom (df) associated with t test comparing treatment and control groups at outcome | | |
| Exact significance level associated with two | | Do not use a cutoff value for statistical significance in this space. |

| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| group independent t-test | | |
| Value that p was reported being less than for independent group t-test | | This is the p value the authors selected as the threshold for statistical significance, usually .10, .05, .01, or .001. |
| **t-statistic: information for Tx vs. Co group at outcome (pre-intervention)** | | |
| t value – pre-test (baseline) comparison between treatment and control group | | Be sure to use the t value that compares the means.<br><br>Should be an independent t test, not a paired t test. |
| df associated with t test comparing treatment and control groups at baseline | | |
| Exact significance level | | Do not use a cutoff value for statistical significance in this space. |
| **f statistic** | | |
| f value – post-test comparison between treatment and control groups | | Be sure to use the F value that compares the means of the Tx versus the Co groups.<br>Do NOT use a F-test that compares mean differences or change scores.<br>Do NOT use a F-test value that compares two or more groups over time.<br>Do NOT use an F-value that examines an interaction effect (e.g. group x time) |
| Degrees of freedom (df) associated with f-test | | |
| Exact significance level associated with f-value above | | Do not use a cutoff value for statistical significance in this space. |
| Value that p was reported being less than for f-value above | | This is the p value the authors selected as the threshold for statistical significance, usually .10, .05, .01, or .001. |
| **Correlation coefficient** | | |

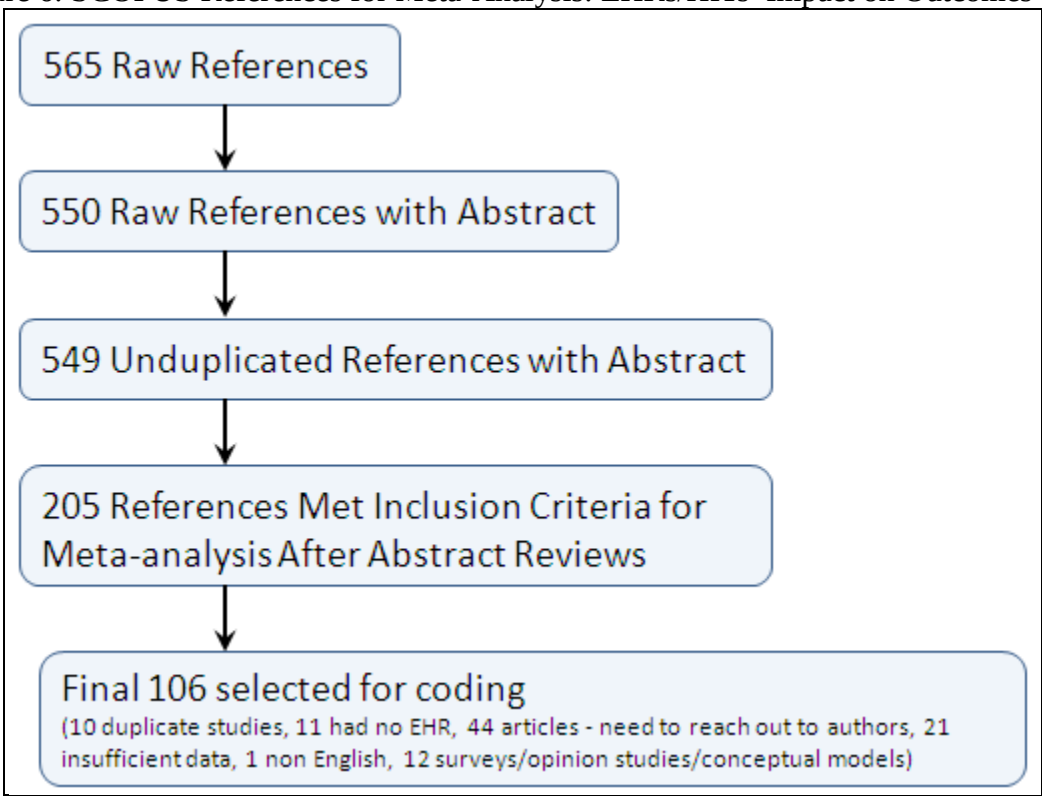
| Variable | Data/Code | Instructions/Comments |
|---|---|---|
| R | | |
| **Odds Ratio** | | |
| Success rate of Tx group post-intervention | | Code success rates as proportion of the group who were successful post-intervention (# successful Tx Ss/# Tx Ss)<br>Do NOT include % sign |
| Success rate of Co group post-intervention | | Code success rates as proportion of the group who were successful post-intervention (# successful Co Ss/# Co Ss)<br>Do NOT include % sign |
| Success rate of Tx group pre-intervention | | Code success rates as proportion of the group who were successful pre-intervention (# successful Tx Ss/# Tx Ss)<br>Do NOT include % sign |
| Success rate of Co group pre-intervention | | Code success rates as proportion of the group who were successful pre-intervention (# successful Co Ss/# Co Ss)<br>Do NOT include % sign |
| Value of Chi-square statistic | | |
| Degrees of freedom (df) associated with chi-square test | | |
| Exact significance level associated with chi-square value above | | |
| *VIII. Miscellaneous* | | |
| Key conclusions of the study authors | | |
| Comments and/or observations of the coders | | |

CC = Definitions of terms comes from the http://www.cochrane.org/glossary/5#term82

**Results of sample coding of SCOPUS articles**

Given the large number of articles selected into the meta-analysis process, we present the summary findings of the process based on the 205 SCOPUS abstracts that were selected based on the search strings created for SCOPUS. We started with the 565 SCOPUS abstracts that were identified using the search strings and the study inclusion criteria that have been defined earlier in this report. First abstracts were reviewed for inclusion based on the three criteria, contained information on EHR/patient management system, patient and/or system outcomes, had data that could be used for calculation of effect size. Our final selection yielded 205 abstracts for inclusion based on the following steps (Refer Figure 6).

Figure 6: SCOPUS References for Meta-Analysis: EHRs/HITs' Impact on Outcomes

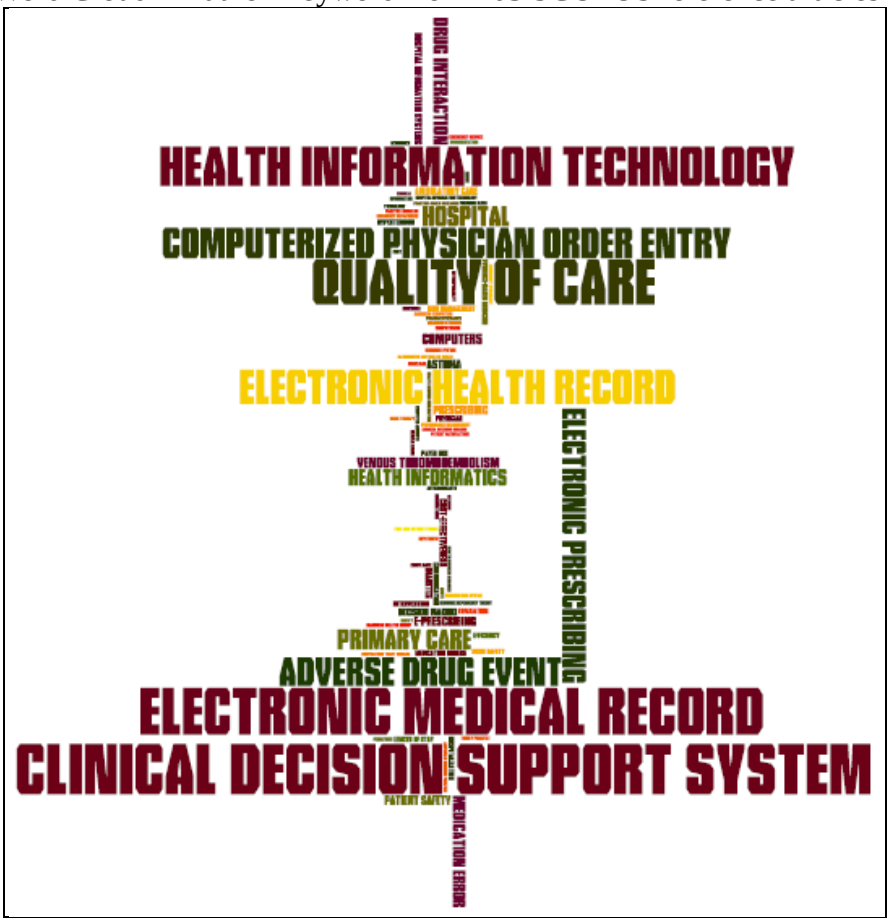



Of the 205 abstracts that were selected based on the inclusion criteria, a defined HIT tool (*i.e.* EHR, CDSS, eRx) and a clear health outcome being measured at the system

and/or patient level. After the 205 full articles were pulled for final coding, we had 10 articles that had to be grouped as they were not distinct studies. We had an attrition rate of 48% starting with the universe of 195 studies. Figure 6 provides details for the reasons other studies were excluded.

Additionally, we wanted to display the frequency of the key words selected by the authors based on the 195 SCOPUS articles that were selected for review based on the exclusion criteria. We used the web site http://www.wordle.com to generate "word clouds". Word clouds are graphical displays that illustrate how often various phrases occur in blocks of text. Responses were loaded into the survey's open-ended questions into Wordle, which generated the following word cloud (Refer Figure 7).

Figure 7: Word Cloud – Author Keyword from 205 SCOPUS reference articles



Even though word clouds are a simplistic method of analysis, Figure 6 captures the essence of what the majority of articles are about. It is not surprising to see words like, HIT, EMR, EHR, CDSS, CPOE, eRx, adverse drug events stand out, when we are conducting a meta-analysis to study the relationship between HIT and quality of care.

# Chapter 4 – Discussion

One out of every five ARRA dollars was appropriated toward HIT. This investment in HIT in the last decade and especially since 2009 warranties a good meta-analysis that can establish beyond doubt the evidence for adoption of EHRs and other HIT tools that can improve and enhance the quality of care in significant ways in all the IOM domains of quality. Additionally, we should be able to produce systematic evidence on what works, how it works, and what needs to be done to have a successful implementation.

It is unfortunate that despite the modified 2009 PRISMA guidelines being published and the 1996 QUORUM guidelines being available to the community of researchers, the quality of the systematic reviews and the meta-analysis has not improved substantially. The question that we need to ask is, are we funding research that answer questions that still remain unanswered conclusively, or are the questions difficult to answer and as a result we are funding and publishing research that does not answer the questions conclusively, or is the quality of the publications inferior and lacking sufficient detail so that studies cannot be coded appropriately for a meta-analysis. All the reasons stated above are true to some extent. The most important point is that we are unable to demonstrate conclusively the value of HIT after almost two decades of research. We have been unable to mine the data that is being published in a way that lends itself to quick analysis and impact on operations.

First, we present a methodology which takes the pain out of the process for creating a database that can be used as a source of truth for tracking articles which are selected into the study based on the PRISMA flowchart guidelines. This step is important

and often difficult to keep track of given the sheer number of articles that are selected into the study at first step. Additionally, we created a simpler process for managing the import of selected studies into a database using SQL and C# applications in comparison to the most commonly available reference management tools like RefWorks and/or EndNote. We want to take this automation further by comparing the results of hand-coded articles with articles coded using natural language processing (NLP) algorithm's to populate the codebook and Lucene, an opensource coding application that is available for parsing and coding data based on vocabularies that are created based on the codebook.

Our goal was to help in the community of researchers by creating a tool that would help reduce the time it takes to complete a meta-analysis. I think we have performed that task successfully. Our codebook is ready for implementation and usage. We erred on the side of a fine granularity so that it would be appealing to people that like to code most everything and those that want to code at a less granular level are also accommodated. In each section we added several more data elements than what the Cochrane checklist lists for data extraction and data collection.

For example in the section on study characteristics, not only do we capture the information about when the study was done, who coded the study, citation and contact details, but we also capture the information on where the study was done, the setting in which the study was done, descriptors of the study setting, like size of practice/hospital, number of physicians and how was the study funded. The sub-domains under this category are study identifiers and study setting.

We left the eligibility and the methods section same as that of the Cochrane checklist. In the eligibility section we confirm eligibility for inclusion and record the

reason for exclusion. In the methods section, we capture details of the study design, study duration, sequence generation, allocation sequence concealment, blinding, and any other concerns about bias.

The participant section is quite a bit different from what is recommended in the Cochrane Handbook. This section was a little challenging to develop when it came to participant characteristics. Typically, in research studies we define the population/sample that is being studied. In this case we define the patients that are impacted and we are studying the result of the physician behavior change on the patient. Consequently, we created a section where we capture the practitioner characteristics, followed by patient characteristics. This section was guided to a great extend by the 106 SCOPUS articles that we reviewed for creating the codebook. Information on physician/healthcare provider and patient characteristics (*i.e.* total number, setting, diagnostic criteria, age, sex, country, co-morbidity, socio-demographic (race, ethnicity, household income, education, insurance type), and year the data were collected).

In the interventions section, we capture the details about the people who delivered the intervention and people to whom the intervention was delivered; what part of the treatment process is the intervention being delivered; type of specialist delivering the intervention; years of experience of the specialist since education; training details and details about the EHRs/CDSSs. This information is likely to help answer questions such as, under what conditions does the implementation of EHRs lead to better system or patient outcomes or what can we do to increase the likelihood on improved outcomes.

The section on outcomes is focused on clear identification of outcomes and their operational definitions, frequency and time-points of collection, unit of measurement,

IOM domains targeted for quality, information on standardized tools, scoring details, and other relevant instrumentation information. We created specific sections on system and patient outcomes. We also created sub-sections to record specific outcomes that are either defined standards for diseases. We think this will ultimately lead to being able analyze the results of the complete meta-analysis in way that we can say with confidence that CDSS/eRx/EHRs improve the following outcomes.

The section on results is organized to capture relevant pieces of data reported for experimental/control group such as sample size, mean, standard deviations, standard error, effect size, hypothesized effect size, mean difference between the compared groups, and test values (*e.g.* Chi square, t-test, f-test, logistic regression variable, correlation, degrees of freedom, odds ratio, inter-rater reliability). In addition, other relevant study characteristics that may be of significance, and any other biases that may have impact on how study findings should be interpreted are also captured.

One of the main considerations when conducting meta-analysis is to identify and avoid bias. It is always easy to find studies that have larger effect sizes, because those are more likely to be published in higher value journals, published more times, and cited more often. Also, as researchers we are less likely to publish non-significant findings, and even if people write non-significant finding, editors are less likely to publish such studies. Hence, for a meta-analysis to be complete, the non-peer reviewed literature must be reviewed systematically so that likelihood of finding as many relevant studies with significant and non-significant findings is increased.

The miscellaneous section is used for recording coder observations, key conclusions of the study authors, etc.

Lastly, based on the SCOPUS review results, we believe that after reviewing the 47,000 abstracts, we will have at least approximately eight thousand articles that will need full review to complete a comprehensive meta-analysis.

**Observations and Preliminary Recommendations**

Based on the detailed review of the SCOPUS studies, the following observations may be useful to fellow researchers:

Many articles were based on the practitioners' perception/opinion/belief about what EHRs/HIT can do for improved system and patient outcomes. These studies could not be added to the meta-analysis as they do not provide actual evidence about what happened in the practitioners practice. It would have be useful, if in addition to practitioners surveys about their beliefs they had also measured actual performance of these practitioners based on EHR implementation and consequent changes on patient outcomes and /or practice workflow.

Other articles point to the fact that even the same EHR can be implemented differently and so what features are turned on in the implementation, how people are trained to use EHRs, all these factors impact the resulting benefits that are experienced by the patient and the communities.

There are still too many specialized systems that do not interoperate. One goal that we can all agree to- is the goal that having access to information at the right time, for the right patient is very important for us to create a safe and informed system of health care delivery.

There is an increase in the development of EHRs that have integrated systems that use algorithms to successfully identify patients for early interventions based on guidelines-based care. As researchers start studying these implementations more rigorously, the case for HIT will be stronger than it is currently.

The reality is that the healthcare system is complex. We propose that interaction between the HIT/EHRs, health care practices, and the individual is a complex adaptive system; and that both inter- and intra-organization environments will impact outcomes. We will need to explore the relationship between these complex systems, which must interoperate successfully to deliver seamless care with improved treatment outcomes. These complex systems (hospitals, physician practices, ancillary services, etc.) create, through interaction, unknown emergent properties that influence system and patient outcomes.

Finally, we believe that if done right meta-analysis will help evaluate the existing literature so that we can improve our understanding of the complex health care system that is constantly evolving.

# Chapter 5 – Summary and Conclusions

In summary, this capstone has produced a codebook that can be used by many researchers that are planning to conduct a meta-analysis to review impact of HIT interventions on patient outcomes and or system outcomes. This codebook will save time of other researchers so that instead of taking six to nine months to create a codebook, they can start with the search and retrieval process and start coding so that they can *speed-up* the slow process of meta-analysis.

### Immediate Next Steps

Meta-analysis can take a long-time to complete (at least a year) and there should be some resources dedicated to evaluating how Natural Language Processing (NPL) could be of use to creating a process for coding articles in meta-analysis that is not manual. As a result of this capstone, we are getting together a group of inter-disciplinary experts that have experience in use of NLP who will attempt to further refine the simple automatic computerized coding process that we developed and tested in this study. The questions we want to be able to answer are:

- By what percent can we reduce the manual coding burden?
- If we are able to achieve a 25% reduction in manual coding, is it worth it?
- How much time would it save and how does it impact the meta-analysis timeline?

The investigation of the creation of an automatic coding mechanism for this type of research is potentially a unique and innovative tool that could be more widely applied

in future meta-analysis projects. The automated method will be compared to hand-coded articles. If the automated coding has a low error rate, then we would have contributed to the field by creating both a tool and a mechanism that can reduce the time that is needed to conduct meta-analysis. To this end we will pilot the two ways of article-coding on a sample of 50 articles. We are convinced that this innovative automated process will speed up the manual laborious coding process for at least half of the data elements and potentially be a widely applicable and extendable approach.

The SQL Server database will be expanded to allow for the storage of coding used to categorize individual references and a web application will be created to allow users to browse references stored in the SQL database. They can both code them and add comments about them. This web application will also allow for the creation of additional meta-analyses within the database; eventually, it will allow for the importation of data from several raw reference sources and the web app will ultimately allow for the creation of import text files for RefWorks and RevMan.

**A network of meta-analysts and coders**

Another recommendation, that follows from the work undertaken for this capstone is the need for preparing researchers in graduate schools to understand both the importance of conducting meta-analysis but also the ability to evaluate systematic reviews and meta-analysis that are published.

Most meta-analysis that we read, were done manually by a group of researchers. We firmly believe that it is time for this group to be inter-disciplinary and to be comprised of content experts, informaticians, programmers, natural language experts,

research librarians, and users of these systematic reviews and meta-analysis. We think we need to start thinking about a network of people who work on a meta-analysis using technologies and protocols that we started in this capstone and we will set-up an alert process so that we can keep the search current and the meta-analysis current. One of the challenges of meta-analysis is that it takes too long and so by the time one is finished, there is another body of evidence that has to be reviewed. Currently, all databases allow you to save the searches and set-up alerts. We believe that this functionality, integrated with an ETL into out C# application, will make the process less onerous. In the future, we see a new type of meta-analysis where centralized repositories allow volunteer researchers to code articles in real time as everything is set-up within a web-service portal.

We continue to be surprised at the absence of a call from the policy leaders and funders in HIT for a review on the ROI in HIT given through the lens of systematic reviews and meta-analysis before funding additional HIT studies. Lastly, our team wants to write a grant so that the proposed meta-analysis can be funded so that we can conclusively answer the question about the impact of EHRs/HIT on patient and system outcomes using the created instrument found in this project.

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# Appendices

Appendix A - Search strings for the databases as created by the reference librarian.

## Database: PUBMED Search Strings

**Revised Dec 18 2012** – first run Nov 6 2012
Limits: **Publication Years 1996-10/31/2012**. Human only. English Abstract only.

**1 COST BENEFIT**
(("Cost-Benefit Analysis"[Majr]) OR cost benefit analysis OR "Quality of Health Care"[Majr]) OR ("Quality Assurance, Health Care"[Majr]) OR ("Outcome Assessment (Health Care)"[Majr]) OR (improved patient outcome* OR patient outcome*) OR ("Health Care Evaluation Mechanisms"[Majr]) OR ("Data Collection"[Mesh]) OR ("Health Expenditures"[Majr] OR healthcare expenditure* OR health care expenditure* OR healthcare cost* OR health care cost* OR hospital cost*) OR (healthcare quality improvement OR health care quality improvement OR quality of healthcare OR quality of health care OR "Health Care Quality, Access, and Evaluation"[Majr] OR "Health Care Costs"[Majr] OR "Cost Savings"[Mesh] OR cost benefit*))
12/19/12 Hits = **4,947,160**

**2 CDSS OR ELECTRONIC HEALTH RECORDS OR EMR OR HIS**
("Patient Identification Systems"[Majr]) OR CDSS OR ("Decision Support Systems, Clinical"[Mesh]) OR (“Decision Support Techniques”[Mesh] OR “Decision Support Systems, Management”[Mesh])OR ("Electronic Health Records"[Majr] OR EHR* OR electronic health record* OR electronic health information OR electronic medical record* OR EMR* OR EHR implementation) OR (“Medical Order Entry Systems”[Mesh] OR "Medical Records Systems, Computerized"[Majr] OR health information technolog* OR hospital information system*) OR (decision support OR health care decision support OR healthcare decision support) OR (“Picture Archiving Communication System*” OR PACS)
12/19/12 Hits = **167,197**

**3 EVIDENCE BASED MEDICINE/EBM/GUIDELINES**
(("Evidence-Based Practice"[Majr]) OR "Evidence-Based Medicine"[Majr] OR EBM OR evidence-based medicine OR evidence based practice OR evidence-based practice OR healthcare guideline* OR health care guideline* OR standard of care* OR hospital guideline* OR practice guideline* OR standardized guideline*))
12/19/12 Hits = **188,436**

**4 E-PRESCRIBING/DRUG DELIVERY**
("Electronic Prescribing"[Majr]) OR "Clinical Pharmacy Information Systems"[Mesh] OR electronic prescription* OR electronic prescribing OR e-prescription* OR e-prescribing OR medication system* OR clinical pharmacy information system* OR pdss OR ("Pharmacy Decision Support System") OR computerized prescribing OR

computerized prescription* OR drug monitoring OR adverse drug event* OR medication error* OR "computerized physician order entry system*" OR "computerized patient order entry system*" OR cpoe OR ("computerized medication administration record*" OR CMAR*)
12/19/12 Hits = **107,091**

**5 PUBMED TOPIC SPECIFIC SEARCH QUERY**
(health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic health Record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*" OR cmar)
12/19/12 Hits = **16,592**

# Database: SCOPUS and EMBASE Search Strings

**Revised Dec 18 2012** – first run Nov 6 2012
*Note: ***EMBASE*** database is included and is a part of the *SCOPUS* database
* Note: Run these search strings in SCOPUS "**Advanced Search**" Page (not basic search)

**1 COST BENEFIT/COST EFFECTIVENESS**
"Cost-Benefit Analysis" OR cost benefit analysis OR cost-benefit analysis OR hospital cost* OR "Quality of Health Care" OR "Outcome Assessment" OR "Health Care Evaluation Mechanisms" OR "Health Expenditures" OR healthcare expenditure* OR health care expenditure* OR healthcare cost* OR health care cost* OR healthcare quality improvement OR health care quality improvement OR quality of healthcare OR quality of health care OR "Health Care Quality Access, and Evaluation" OR "Cost Savings" OR cost benefit* AND PUBYEAR > 1995
12/19/12 SCOPUS/EMBASE Hits = **20,314**

**2 CDSS OR ELECTRONIC HEALTH RECORDS OR EMR**
("Electronic Health Record*" OR ehr* OR electronic health information OR electronic medical record* OR electronic health care record* OR emr* OR ehr implementation OR "Patient Identification System*" OR cdss OR "Clinical Decision Support System*" OR "Decision Support Technique*" OR "Decision Support Systems Management" OR "Medical Order Entry System*" OR "Medical Records System*" OR health information technolog* OR hospital information system* OR decision support OR health care decision support OR healthcare decision support OR health information exchange OR hie OR electronic health data OR personal health data OR personal health record* OR health records personal OR ehealth OR e-health OR e-health OR medical records system* OR medical records system computerized OR computerized patient medical record* OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record*) AND PUBYEAR > 1995
12/19/12 SCOPUS/EMBASE Hits = **2,436**

**3 EVIDENCE BASED MEDICINE/EBM/GUIDELINES**
("Evidence-Based Practice" OR "Evidence-Based Medicine" OR ebm OR evidence-based medicine OR evidence based practice OR evidence-based practice OR healthcare guideline* OR health care guideline* OR standard of care* OR hospital guideline* OR practice guideline* OR standardized guideline*) AND PUBYEAR > 1995
12/19/12 SCOPUS/EMBASE Hits = **86,781**

**4 E-PRESCRIBING/DRUG DELIVERY**
SCOPUS: Drug Delivery/E-Prescribing search strings (updated 4-19-2013). Run the search then apply YEARS limits from left-hand column (1996-2012)
1 - "Electronic Prescribing" OR "Clinical Pharmacy Information System*" OR "electronic prescription*" OR "electronic prescribing" OR "e-prescription*" OR "e-prescribing" OR clinical pharmacy information system* OR medication system* OR

"patient order entry system*" OR cpoe OR poe OR clinical drug delivery OR drug monitoring OR decision support systems, clinical

2 - adverse drug reaction reporting systems OR databases, factual OR drug interactions OR drug monitoring

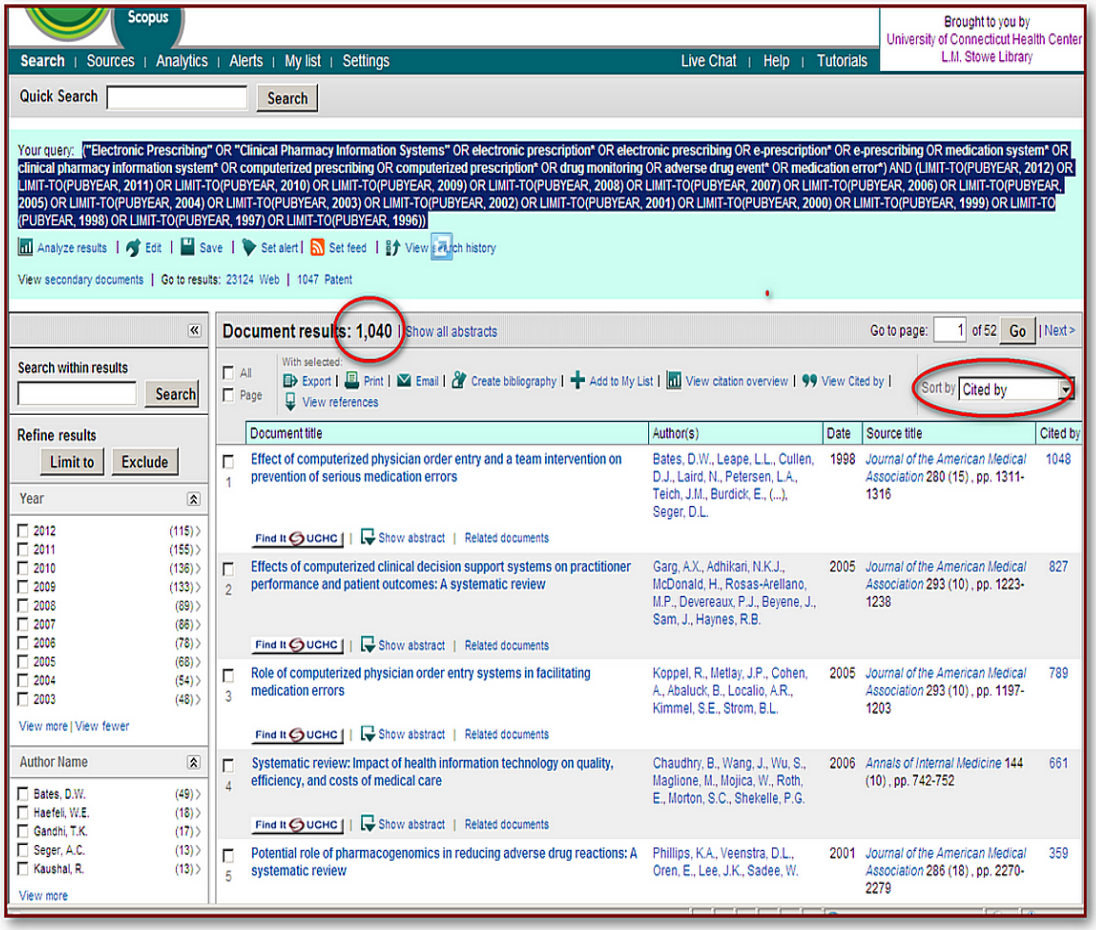
3 - computerized prescription* OR computerized prescribing OR "clinical pharmacy information system*" OR "medical order entry system*" OR electronic prescription* OR electronic prescribing OR electronic medication management OR drug-allergy OR drug-drug OR formulary decision support OR drug administration OR drug information OR pharmaceutical preparation* OR drug therapy, computer-assisted OR medication error* OR medication systems, hospital OR adverse drug event* OR prescribing error OR prescription error* OR patient order entry system* OR patient identification system*.

**5 PUBMED TOPIC SPECIFIC SEARCH QUERY**

health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic health record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*" AND PUBYEAR > 1995

12/19/12 SCOPUS/EMBASE Hits = **213**

SCOPUS Screenshot (Dec 3 2012)



# Database: Web of Science Search Strings

**Revised Dec 19 2012** – first run Nov 6 2012
Note: Add Publication Years 1996-10/31/2012 after search string is run; limit search to SCI and SSCI only (not Arts & Humanities Index)

**1 COST-BENEFIT or COST EFFECTIVENESS/HEALTH CARE QUALITY, EXPENDITURES**
TS=("Cost-Benefit Analysis" OR "cost benefit analysis" OR "cost-benefit analysis" OR "Quality of Health Care" OR "Outcome Assessment" OR "patient outcome*" OR "Health Care Evaluation Mechanism*" OR "Data Collection" OR "Health Expenditure*" OR "healthcare expenditure*" OR "health care expenditure*" OR "cost of healthcare" OR "healthcare cost*" OR "health care cost*" OR "hospital cost*" OR "healthcare quality improvement" OR "health care quality improvement*" OR "quality of healthcare" OR "quality of health care" OR "Health Care Quality Evaluation" OR "Healthcare Quality Evaluation" OR "Cost* Saving*" OR "cost benefit*")
12/19/12 Web of Science=**88,581**

**2 ELECTRONIC HEALTH RECORDS OR EMR OR CLINICAL DECISION SUPPORT**
TS=("Electronic Health Record*" OR EHR OR "Electronic Medical Record*" OR EMR OR "Electronic Patient Record*" OR "Patient Identification System*" OR cdss OR "Clinical Decision Support System*" OR "computerized provider order entry" OR "Decision Support Technique*" OR "Decision Support Systems Management" OR "decision support systems clinical" OR "decision support technique*" OR "electronic health information" OR "EHR implementation" OR "EMR implementation" OR "Medical Order Entry System*" OR "Medical Record* System*" OR "health information technolog*" OR "hospital information system*" OR "decision support" OR "health care decision support" OR "healthcare decision support" OR "picture archiving communication* system OR PACS OR Ehealth OR E-health OR automated medical record system*" OR "data exchange network*" OR "consumer health informatic*" OR "knowledge retrieval system*" OR "electronic health communication*" OR "patient decision support")
12/19/12 Web of Science=**26,095**

**3 EVIDENCE BASED MEDICINE/EBM/GUIDELINES**
TS=("Evidence-Based Practice" OR "Evidence-Based Medicine" OR ebm OR "evidence-based medicine" OR "evidence based practice" OR "healthcare guideline*" OR "health care guideline*" OR "standard of care*" OR "hospital guideline*" OR "practice guideline*" OR "standardized guideline*")
12/19/12 Web of Science=**36,729**

**4 E-PRESCRIBING/DRUG DELIVERY/CPOE**
TS=("Electronic Prescribing" OR "Clinical Pharmacy Information System*" OR electronic prescription* OR electronic prescribing OR e-prescription* OR “computerized physician order entry system*” OR “computerized patient order entry system*” OR

CPOE OR e-prescribing OR medication system* OR computerized prescribing OR computerized prescription* OR adverse drug event* OR medication error* OR PDSS OR “Pharmacy Decision Support System” OR PHYSICIAN ORDER ENTRY OR ADVERSE DRUG EVENT* OR PRESCRIPTION ERROR*)
12/19/12 Web of Science=**51,003**

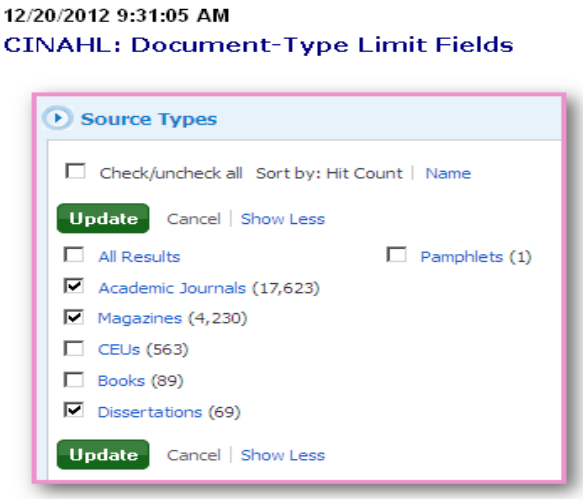
**5 PUBMED TOPIC SPECIFIC SEARCH QUERY**

TS=("health information exchange" OR hie OR "regional health information organization" OR "electronic health data" OR "personal health data" OR "personal health record*" OR "Health Records Personal" OR "Personal Health Record*" OR ehealth OR e-health OR E-health OR "medical informatics application*" OR "medical records system*" OR "medical records system computerized" OR "computerized patient medical record*" OR "automated medical record system*" OR "automated medical record* system*" OR "computerized medical record*" OR "computerized patient record*" OR "computerized patient medical record*" OR "electronic health record*" OR "electronic patient record*" OR "electronic medical record*" OR "electronic healthcare record*" OR "electronic health care record*")
12/19/12 Web of Science= **9,549**

# Database: Cumulative Index to Nursing & Allied Health Literature (CINAHL) Search Strings

Created on December 5 – Revised December 20 2012 Note: Remember to limit for years 1996-October 2012

Note: There is "smart text" search and there is Major Subject Heading search in this database. These search strategies will retrieve very different results. If you have time, try it both ways. Also limit to these document types (screenshot):




**1 – CINAHL Headings for Cost Benefit Analyses/Outcome Assessment**
(MM "Cost Benefit Analysis") OR (MM "Costs and Cost Analysis") OR (MM "Health Care Costs") OR (MM "Health Care Delivery, Integrated") OR (hospital cost*) OR (MM "Outcomes (Health Care)") OR (MM "Health Services Needs and Demand") OR (MM "Adverse Health Care Event") OR (MM "Health Care Delivery") OR (MM "Outcome Assessment") OR (MM "Patient Centered Care") OR (MM "Continuity of Patient Care") OR (MM "Progressive Patient Care") OR (MM "Quality of Care Research") OR (MH "Quality of Care Research") OR (MM "Quality of Health Care") OR (MM "Cost Control") OR (MM "Cost Savings") OR (MM "Economic Aspects of Illness") OR (MM "Process Assessment (Health Care)") OR (MM "Quality Assessment") OR (MM "Quality Control (Technology)") OR (MM "Health Screening") OR (MH "Continuity of Patient Care")
On 12/20/12 CINAHL= **76,661.** Copy and paste this perma-link to replicate:

http://ezproxy.lib.uconn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=(MM+%26quot%3bCost+Benefit+Analysis%26quot%3b)+OR+(MM+%26quot%3bCosts+and+Cost+Analysis%26quot%3b)+OR+(MM+%26quot%3bHealth+Care+Costs%26quot%3b)+OR+(MM+%26quot%3bHealth+Care+Delivery%2c+Integrated%26quot%3b)+OR+(hospital+cost*)+OR+(MM+%26quot%3bOutcomes+(Health+Care)%26quot%3b)+OR+(MM+%26quot%3bHealth+Services+Needs+and+Demand%26quot%3b)+OR+(MM+%26quot%3bAdverse+Health+Care+Event%26quot%3b)+OR+(MM+%26quot%3bHealth+Care+Delivery%26quot%3b)+OR+(MM+%26quot%3bOutcome+Assessment%26quot%3b)+OR+(MM+%26quot%3bPatient+Centered+Care%26quot%3b)+OR+(MM+%26quot%3bContinuity+of+Patient+Care%26quot%3b)+OR+(MM+%26quot%3bProgressive+Patient+Care%26quot%3b)+OR+(MM+%26quot%3bQuality+of+Care+Research%26quot%3b)+OR+(MH+%26quot%3bQuality+of+Care+Research%26quot%3b)+OR+(MM+%26quot%3bQuality+of+Health+Care%26quot%3b)+OR+(MM+%26quot%3bCost+Control%26quot%3b)+OR+(MM+%26quot%3bCost+Savings%26quot%3b)+OR+(MM+%26quot%3bEconomic+Aspects+of+Illness%26quot%3b)+OR+(MM+%

26quot%3bProcess+Assessment+(Health+Care)%26quot%3b)+OR+(MM+%26quot%3bQuality+Assessment%26quot%3b)+OR+(MM+%26quot%3bQuality+Control+(Technology)%26quot%3b)+OR+(MM+%26quot%3bHealth+Screening%26quot%3b)+OR+(MH+%26quot%3bContinuity+of+Patient+Care%26quot%3b)&cli0=DT1&clv0=199601-201212&type=1&site=ehost-live

**2– CINAHL Search Strings for EHR/Personal Health Records**

(MM "Medical Records, Personal") OR (MH "Medical Records, Personal") OR (MH "Medical Records") OR (MM "Health Information Management") OR (MH "Electronic Data Interchange+") OR (MH "Patient Record Systems") OR (MM "Patient Record Systems") OR (MH "Computerized Patient Record*") OR (MM "Computerized Patient Record*") OR "electronic health record*" OR EMR OR EHR OR "electronic medical record*" OR "electronic patient record*" OR ("Patient Identification System*") OR ("EMR implementation") OR ("EHR implementation") OR ("Medical Record* System*") OR (individual health record*) OR (patient health record*) OR (automated health record*)

12/20/12 CINAHL= **21,922.** Copy and paste this perma-link to replicate:

http://ezproxy.lib.uconn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=(MM+%26quot%3bMedical+Records%2c+Personal%26quot%3b)+OR+(MH+%26quot%3bMedical+Records%2c+Personal%26quot%3b)+OR+(MH+%26quot%3bMedical+Records%26quot%3b)+OR+(MM+%26quot%3bHealth+Information+Management%26quot%3b)+OR+(MH+%26quot%3bElectronic+Data+Interchange%2b%26quot%3b)+OR+(MH+%26quot%3bPatient+Record+Systems%26quot%3b)+OR+(MM+%26quot%3bPatient+Record+Systems%26quot%3b)+OR+(MH+%26quot%3bComputerized+Patient+Record*%26quot%3b)+OR+(MM+%26quot%3bComputerized+Patient+Record*%26quot%3b)+OR+%26quot%3belectronic+health+record*%26quot%3b+OR+EMR+OR+EHR+OR+%26quot%3belectronic+medical+record*%26quot%3b+OR+%26quot%3belectronic+patient+record*%26quot%3b+OR+(%26quot%3bPatient+Identification+System*%26quot%3b)+OR+(%26quot%3bEMR+implementation%26quot%3b)+OR+(%26quot%3bEHR+implementation%26quot%3b)+OR+(%26quot%3bMedical+Record*+System*%26quot%3b)+OR+(individual+health+record*)+OR+(patient+health+record*)+OR+(automated+health+record*)&cli0=DT1&clv0=199601-201212&type=1&site=ehost-live

**3 – CINAHL Search Strings for Systems Management for EHR / Decision Support**

(MH "Health Information Management") OR (MH "Electronic Data Interchange") OR ("Clinical Decision Support System*") OR ("Decision Support Technique*") OR ("Decision Support Systems Management") OR (MM "Clinical Information Systems") OR (MH "Health Information Systems") OR (MM "Decision Support Systems, Clinical") OR (MH "Hospital Information Systems") OR (MH "Clinical Information Systems") OR ("Medical Order Entry System*") OR ("health information technolog*") OR ("hospital information system*") OR ("clinical decision support") OR (CDSS) OR ("health care decision support") OR ("healthcare decision support") OR (MH "Management Information Systems") OR (MH "Health Information Systems") OR (MH "Electronic Data Interchange") OR (MM "Managed Care Information Systems") OR (MH "Health Information Management") OR (MH "Health Care Information Exchange (Iowa NIC)") OR (MH "Electronic Data Interchange") OR (MH "Health Information Networks") OR (MH "Health Information Systems") OR (MH "Consumer Health Information") OR (MH "Health Information Management Service") OR (MH "Health Plan Employer Data and Information Set") OR (MH "Record Review") OR (MH "Medical Records") OR (MH "Medical Record Linkage") OR (MH "Electronic Order Entry") OR (patient order entry) OR (POE)

12/20/12 CINAHL= **56,592**

**4 –CINAHL Search Strings for E-Prescribing**

("Electronic Prescribing") OR ("Clinical Pharmacy Information System*") OR (electronic prescription*) OR (electronic prescribing) OR e-prescription* OR e-prescribing OR (prescribing error*) OR (medication system*) OR (clinical pharmacy information service*) OR ("computerized physician order entry system*") OR ("computerized patient order entry system*") OR CPOE OR (computerized prescribing) OR (computerized prescription*) OR (drug monitoring) OR (adverse drug event*) OR (drug administration) OR (medication error*) OR (adverse drug reaction*) OR (drug delivery*) OR (drug hypersensitivity) OR PDSS OR ("Pharmacy Decision Support System")

12/20/12 CINAHL= **43,593.** Copy and paste this perma-link to replicate:
http://ezproxy.lib.uconn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=(%26quot%3bElectronic+Prescribing%26quot%3b)+OR+(%26quot%3bClinical+Pharmacy+Information+System*%26quot%3b)+OR+(electronic+prescription*)+OR+(electronic+prescribing)+OR+e-prescription*+OR+e-prescribing+OR+(prescribing+error*)+OR+(medication+system*)+OR+(clinical+pharmacy+information+service*)+OR+(%26quot%3bcomputerized+physician+order+entry+system*%26quot%3b)+OR+(%26quot%3bcomputerized+patient+order+entry+system*%26quot%3b)+OR+CPOE+OR+(computerized+prescribing)+OR+(computerized+prescription*)+OR+(drug+monitoring)+OR+(adverse+drug+event*)+OR+(drug+administration)+OR+(medication+error*)+OR+(adverse+drug+reaction*)+OR+(drug+delivery*)+OR+(drug+hypersensitivity)+OR+PDSS+OR+(%26quot%3bPharmacy+Decision+Support+System%26quot%3b)&type=1&site=ehost-live

AND/OR THIS SEARCH

(MH "Prescriptive Authority") OR (MH "Prescribing Patterns") OR (MH "Clinical Pharmacy Information Systems") OR (MH "Clinical Information Systems") OR (MH "Clinical Laboratory Information Systems") OR (MH "Decision Support Systems, Clinical") OR (MH "Pharmacy Service") OR (MH "Pharmacy Administration") OR (MH "Insurance, Pharmaceutical Services") OR (MH "Health Care Delivery, Integrated") OR (MH "Nursing Care Delivery Systems") OR (MH "Drug Delivery Systems")

12/20/12 CINAHL= **19,397.** Copy and paste this perma-link to replicate:
http://ezproxy.lib.uconn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=(MH+%26quot%3bPrescriptive+Authority%26quot%3b)+OR+(MH+%26quot%3bPrescribing+Patterns%26quot%3b)+OR+(MH+%26quot%3bClinical+Pharmacy+Information+Systems%26quot%3b)+OR+(MH+%26quot%3bClinical+Information+Systems%26quot%3b)+OR+(MH+%26quot%3bClinical+Laboratory+Information+Systems%26quot%3b)+OR+(MH+%26quot%3bDecision+Support+Systems%2c+Clinical%26quot%3b)+OR+(MH+%26quot%3bPharmacy+Service%26quot%3b)+OR+(MH+%26quot%3bPharmacy+Administration%26quot%3b)+OR+(MH+%26quot%3bInsurance%2c+Pharmaceutical+Services%26quot%3b)+OR+(MH+%26quot%3bHealth+Care+Delivery%2c+Integrated%26quot%3b)+OR+(MH+%26quot%3bNursing+Care+Delivery+Systems%26quot%3b)+OR+(MH+%26quot%3bDrug+Delivery+Systems%26quot%3b)&type=1&site=ehost-live

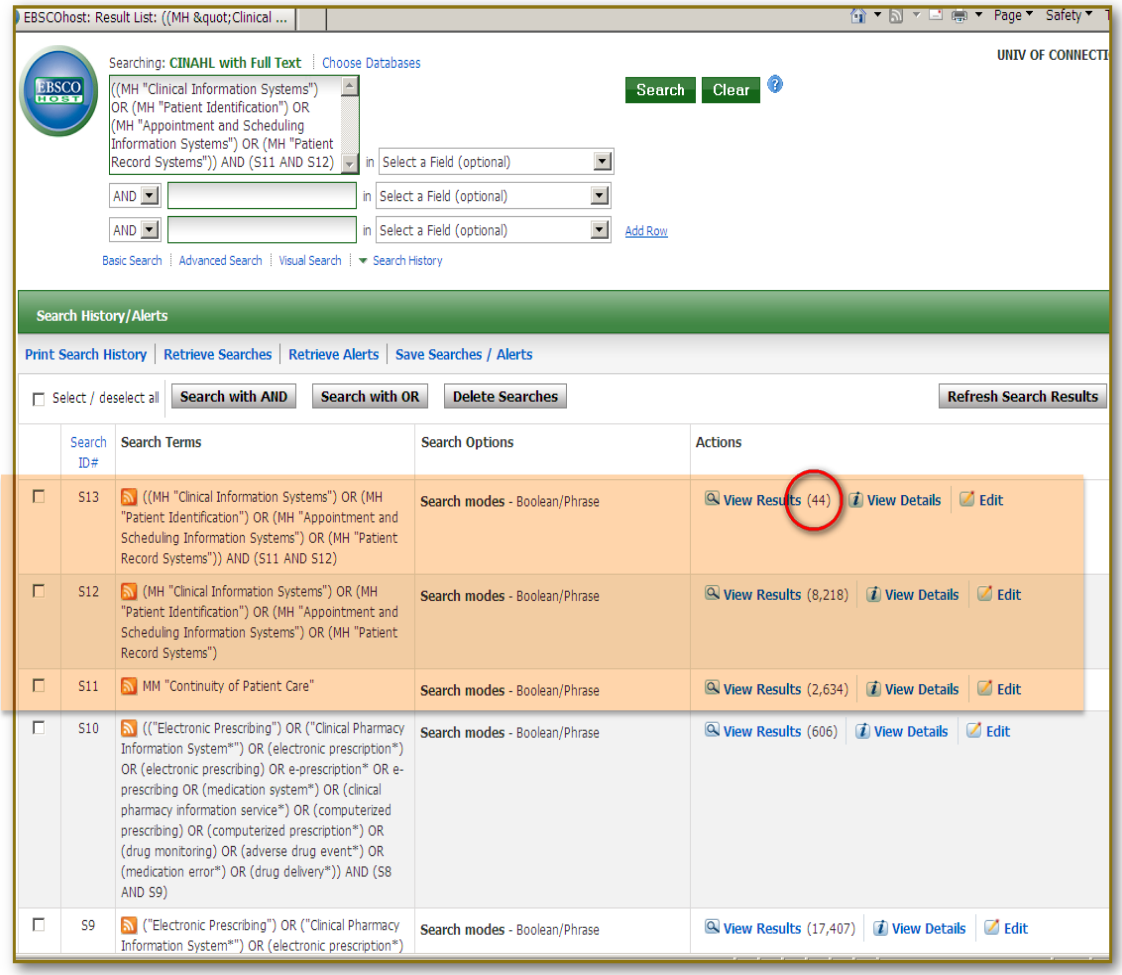
**5 –EHR Search String taken from PubMed Electronic Health Records Topic Query**

((health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR Health Records Personal OR Personal Health Record OR ehealth OR e-health OR E-health OR medical informatics application* OR medical records system* OR medical records system computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR Electronic Health Record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record*))

12/20/12 CINAHL= **10,036.** Copy and paste this perma-link to replicate:
http://ezproxy.lib.uconn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=((health+information+exchange+OR+hie+OR+regional+health+information+organization+OR+electronic+health+data+OR+personal+health+data+OR+personal+health+record*+OR+Health+Records+Personal+OR+Personal+Health+Record+OR+ehealth+OR+e-health+OR+E-

health+OR+medical+informatics+application*+OR+medical+records+system*+OR+medical+records+system+computerized+OR+medical+records+system*+computerized+OR+computerized+patient+medical+record*+OR+automated+medical+record+system+OR+automated+medical+record*+system*+OR+computerized+medical+record*+OR+computerized+patient+record*+OR+computerized+patient+medical+record*+OR+electronic+health+record*+OR+Electronic+Health+Record*+OR+electronic+patient+record*+OR+electronic+medical+record*+OR+electronic+healthcare+record*+OR+electronic+health+care+record*))&cli0=DT1&clv0=199601-201212&type=1&site=ehost-live

12/5/2012 10:56:49 AM
A sample search in CINAHL
Dec 5 2012




**Note: Explode Feature** versus Using **Hand-picked Subject Headings** but not "exploding" them

Example from **CINAHL** – if the term has a + sign next to it, then I exploded it. Exploded means *get all* subject headings that are grouped under the term… not just the actual Subject Heading you wanted. It is a vast way to broaden the scope of your search. Shown below: a string of "Exploded" CINAHL subject headings retrieved 164,000 items (on Dec 5 2012)

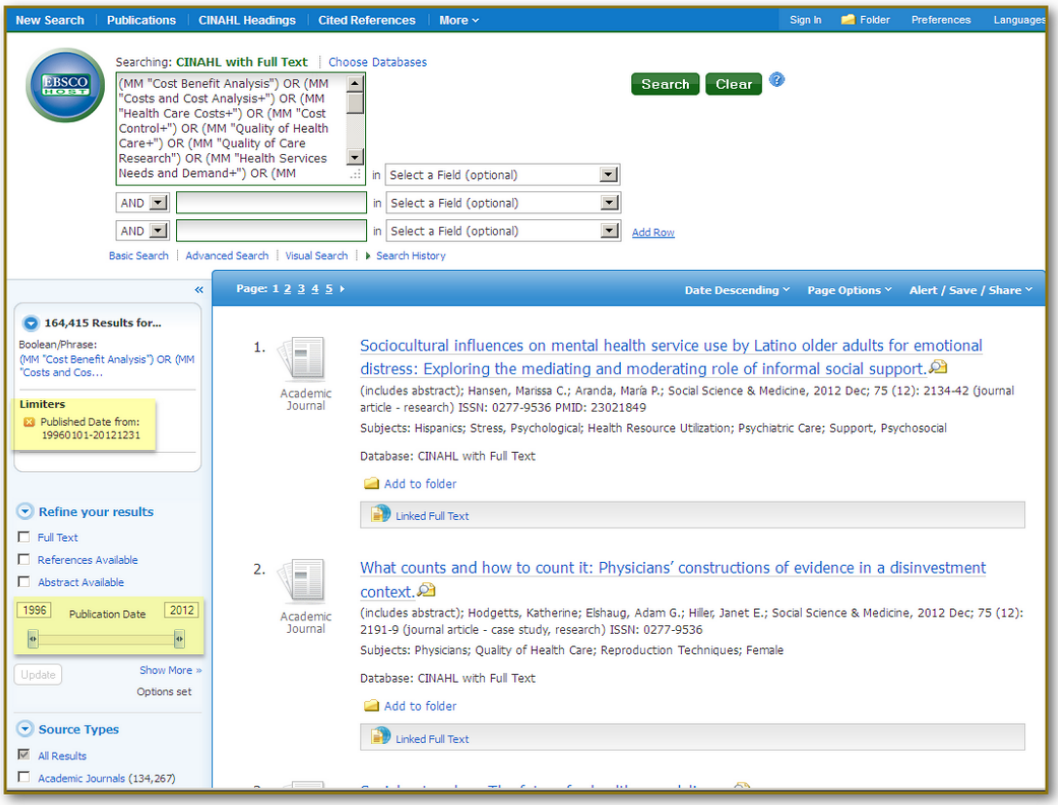
12/5/2012 3:09:19 PM

Re: CINAHL database

I have done search on Cost Benefit Analysis/Outcome Evaluation etc. in what we librarians call an "Exploded" manner and a non-exploded manner. There is a vast difference in number of retrievals - the "Exploded" search string is shown... with 164,000 retrievals.

Doing a Major or Minor Subject Heading Search in CINAHL (without "exploding" the search term) retrieve many less.

Also note that in CINAHL to narrow to your 1996-2012 time frame, you must use the bar on the left-hand side of the screen (shown in Yellow)

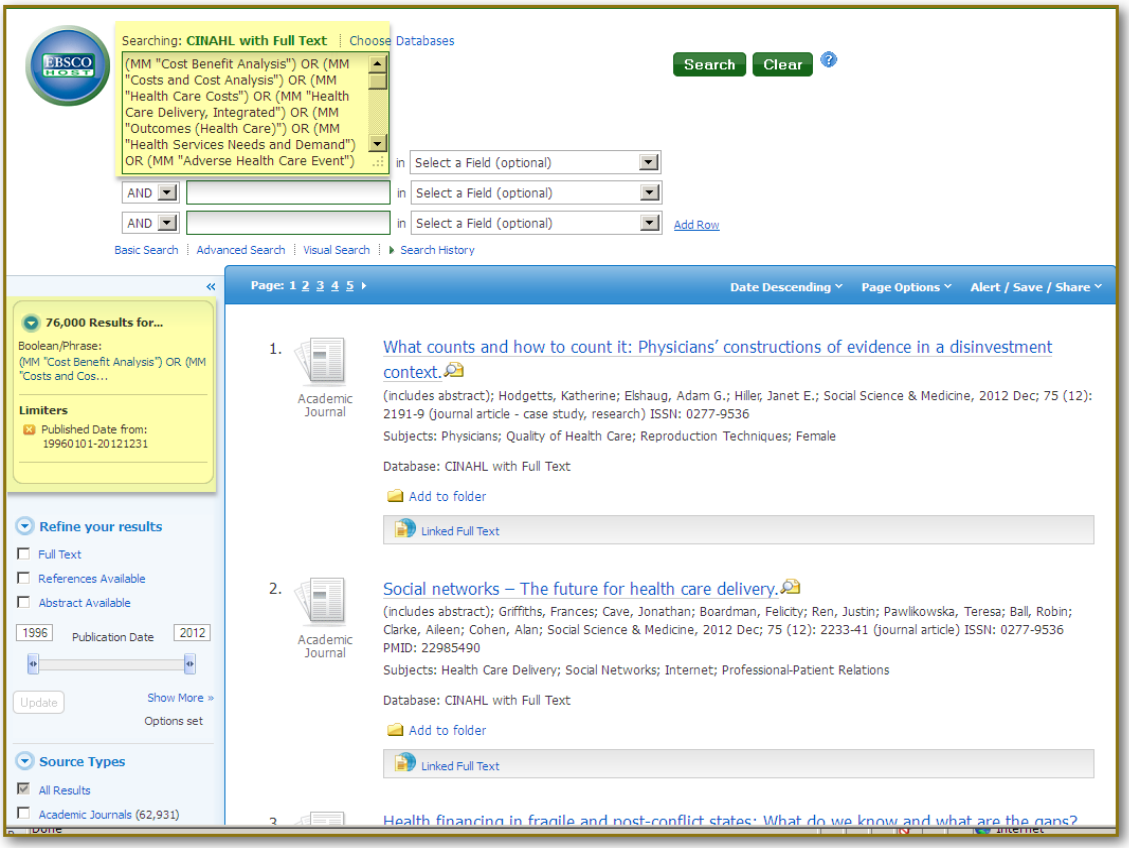



Next: See non-exploded example. Using CINAHL search string of terms which I browsed in the CINAHL thesaurus and then selected one by one, and also by developing a collection of pertinent keywords or keyword phrases, I developed this search string: (MM "Cost Benefit Analysis") OR (MM "Costs and Cost Analysis") OR (MM "Health Care Costs") OR (MM "Health Care Delivery, Integrated") OR (MM "Outcomes (Health Care)") OR (MM "Health Services Needs and Demand") OR (MM "Adverse Health Care Event") OR (MM "Health Care Delivery") OR (MM "Outcome Assessment") OR (MM "Patient Centered Care") OR (MM "Continuity of Patient Care") OR (MM "Progressive Patient Care") OR (MM "Quality of Care Research") OR (MH "Quality of Care Research") OR (MM "Quality of Health Care") OR (MM "Cost Control") OR (MM "Cost Savings") OR (MM "Economic Aspects of Illness") OR (MM "Process Assessment (Health Care)") OR (MM "Quality Assessment") OR (MM "Quality Control (Technology)") OR (MM "Health Screening") OR (MH "Continuity of Patient Care") Using that search string in CINAHL I got = **76,240** on Dec 20, 2012

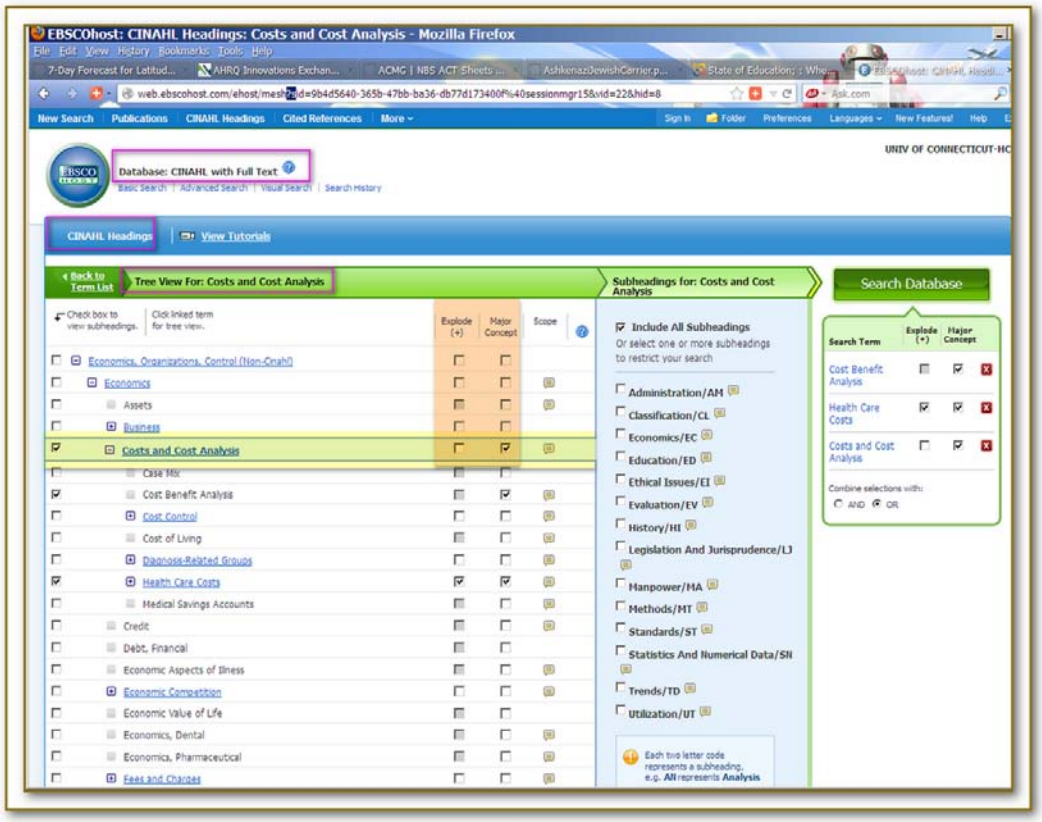
12/5/2012 3:16:40 PM

CINAHL. Example of searc string using only hand-picked subject headings or keywords.

Not using the "explode" feature, there were 76,000 citations




There is a large difference between a **Subject Heading/keyword search,** and using a **group of Subject Headings with "Explode" feature** will pull up vastly different search sets. In this example, 76,000 hits versus 164,000 hits. For this review I <u>have not been using the "Explode"</u> feature available in PubMed or PsycInfo so you need to be aware of that. Next: a screenshot of how a CINAHL subject heading can be either chosen to be searched as an Exploded way or as a Major Heading (MH).



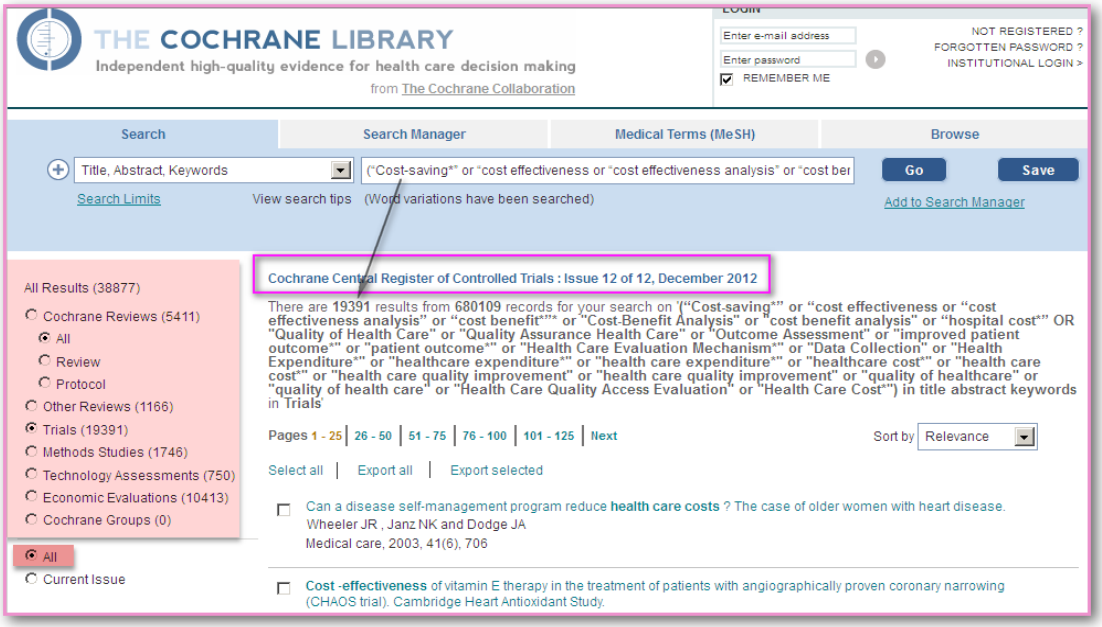

If, after your paper has been submitted for your academic course and credit, we want to re-visit the use of "Explode" search-strings versus the method I have used (i.e., to select pertinent Subject Headings/Indexing terms from the thesaurus attached to that particular database and inventing keyword or key phrase search strings and then searching on both the keywords and the Subject Headings without explosion) then we should meet to go over that. Cochrane reviews require "Explosion" of terms, as an example. But personally, for this project, I did not find it was warranted because you (the person writing the review) are going to do the major filtering, using your own criteria (and human brain). Here is an excerpt from a two page 2009 letter published in Bioinformatics – Vol 25, No. 20, full text at: http://www.lhncbc.nlm.nih.gov/lhc/docs/published/2009/pub2009039.pdf and authored by National Library of Medicine librarians:

"….. the PubMed search algorithm uses relationships between MeSH headings by '**exploding**' the search terms, so that documents indexed with a specific heading will be retrieved by a search on a more general, related heading. PubMed also employs the '**Automatic Term Mapping'** (ATM) feature, which automatically maps a text query to MeSH for improved retrieval results. The benefits of this feature were formally assessed on the TREC collections recently (Lu *et al.*, 2009) and it is found that MeSH query expansion does not always improve retrieval.

## Database: Cochrane Central Register of Controlled Trials Search String

Revised Dec 20 2012, first run December 13 2012 Limits: Publication Years 1996-2012

**Note**: Although Medical Subject Headings (MeSH) terms can be used to search Cochrane, sadly the MeSH search strings that I developed for use in PubMed do not work to search Cochrane exactly the same way. That is why there are different search-strings for Cochrane than those developed for use in PubMed.




**1 Cost Benefits/Quality Improvement/Healthcare Costs**

Cochrane Central Register of Controlled Trials : **19391 results** from 680109 records for your search on ("Cost-saving*" or "cost effectiveness or "cost effectiveness analysis" or "cost benefit*"* or "Cost-Benefit Analysis" or "cost benefit analysis" or "hospital cost*" OR "Quality of Health Care" or "Quality Assurance Health Care" or "Outcome Assessment" or "improved patient outcome*" or "patient outcome*" or "Health Care Evaluation Mechanism*" or "Data Collection" or "Health Expenditure*" or "healthcare expenditure*" or "health care expenditure*" or "healthcare cost*" or "health care cost*" or "health care quality improvement" or "health care quality improvement" or "quality of healthcare" or "quality of health care" or "Health Care Quality Access Evaluation" or "Health Care Cost*") in title abstract keywords in Trials and 1996-2012 only

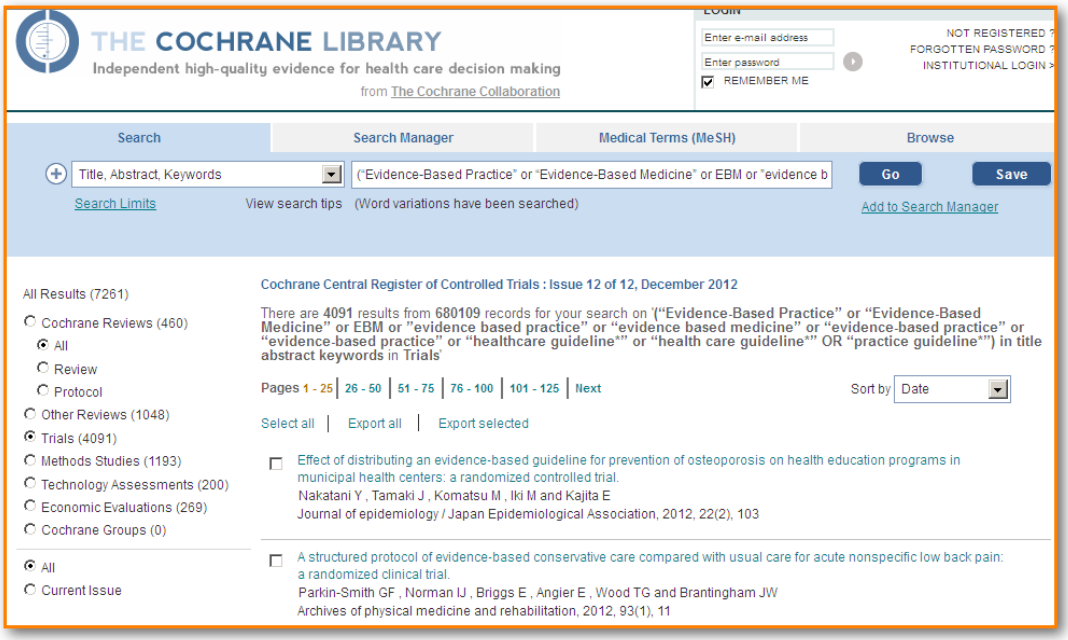
**2 EHR/EMR or Hospital Information Systems or POE**

There are **428 results** from 7646 records for your search on ("Patient Identification System*" or CDSS or "Decision Support Systems Clinical" or "Decision Support Technique*" or "Decision Support Systems Management" or "health record* personal" or "personal health record*" or "Electronic Health Record*" or EHR* or "electronic health record*" or "electronic health information" or "electronic medical record*" or EMR* or "EHR implementation" or "Medical Order Entry System*" or "computerized physician order entry system*" or "computerized patient order entry system*" or CPOE*

or “Patient Order Entry System*” or POE* or “Medical Records Systems Computerized” or “health information technolog*” or “hospital information system*” or “hospital information system*” OR “electronic information system*”) in title abstract keywords – on 12/20/12 Cochrane Central Register of Controlled Trials

3 Evidence Based Medicine OR EBM

There are **4091 results** from 680109 records for your search on (“Evidence-Based Practice” or “Evidence-Based Medicine” or EBM or ”evidence based practice” or “evidence based medicine” or “evidence-based practice” or “evidence-based practice” or “healthcare guideline*” or “health care guideline*” OR “practice guideline*”) in title abstract keywords – on 12/20/12 Cochrane Central Register of Controlled Trials. See below

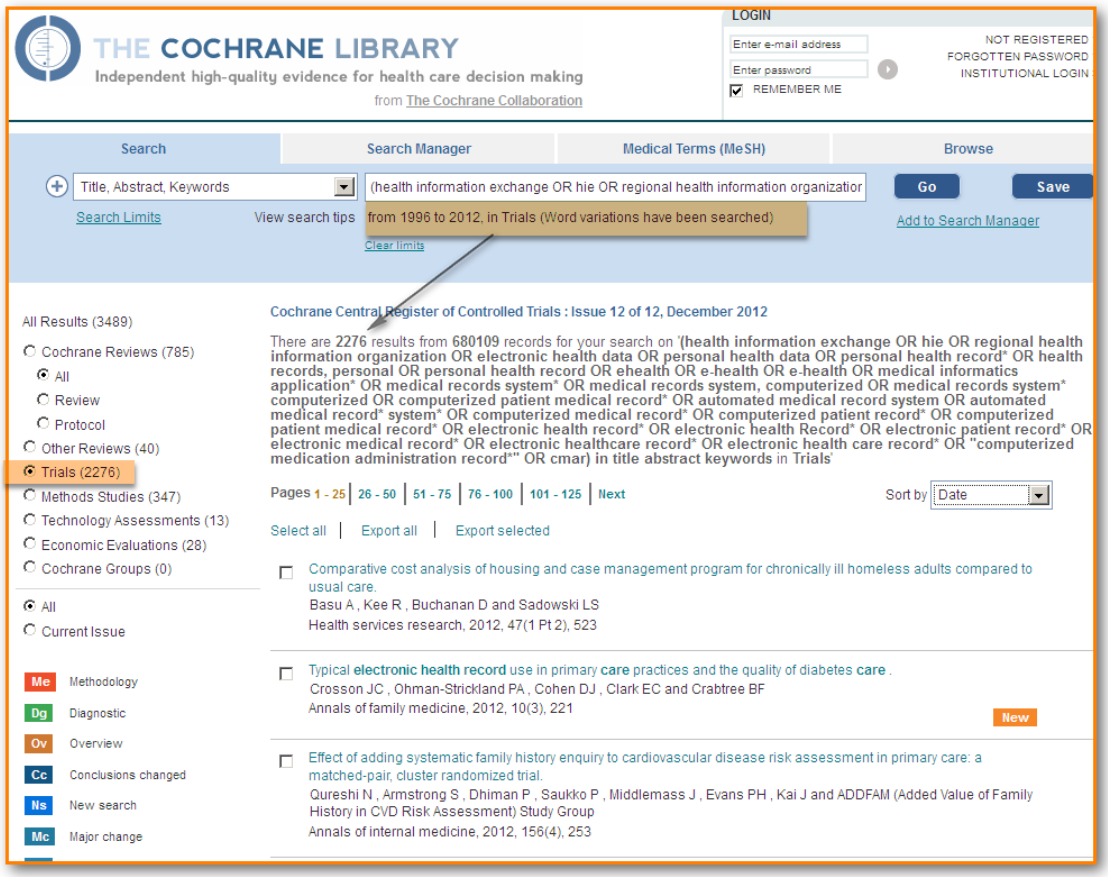



**4 E-Prescribing/DrugDelivery**

There are **87,649 results** from 680109 records for your search on ("Electronic Prescribing" or "Clinical Pharmacy Information Systems" or “clinical patient order entry” or “hospital order entry system” or “electronic prescription*” or “electronic prescribing” or “e-prescription*” or “e-prescribing” or “automated medication system*” or “clinical pharmacy information system*” or “computerized prescribing” or “computerized prescription*” or “drug monitoring” or “adverse drug event*” or “medication error*” or “drug delivery system*” or “computerized patient entry order system*” or CPOE* or “computerized physician entry order system*” or PDSS OR “Pharmacy Decision Support System” or “drug administration” or “drug delivery*” or “drug hypersensitivity*” or "computer-aided therap*”) in title abstract keywords – on 12/20/12 Cochrane Central Register of Controlled Trials.

**5 PubMed Topics Search String:**

There are **2,276 results** from 680109 records for your search on (health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health records, personal OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records system, computerized OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic health Record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record* OR "computerized medication administration record*" OR cmar*") in title abstract keywords – on 12/20/12 Cochrane Central Register of Controlled Trials. – See next page




#5 PubMed search string – Clinical Queries

# Database: PsycInfo Search Strings

Created 12/11/12 and Revised 12/21/12
Smart Search OR Abstract (AB) OR Descriptor (DE) – Jan 1996 through Oct 31 2012 only.

**1 Cost Benefit / Quality of Health Care**
AB ("Cost-Benefit Analysis") OR (“cost benefit analysis”) OR (“cost-effectiveness”) OR (“cost effectiveness”) OR (“hospital cost*”) OR ("Quality of Health Care") OR (DE "Quality of Care") OR (“Quality Assurance Health Care") OR ("Outcome Assessment") OR (“improved patient outcome*”) OR ("Health Care Evaluation Mechanism*") OR ("Health Expenditure*") OR (healthcare expenditure*) OR (“health care expenditure*”) OR (“healthcare cost*”) OR (“health care cost*”) OR (“healthcare quality improvement”) OR (“health care quality improvement”) OR (“quality of healthcare”) OR (“quality of health care”) OR ("Health Care Quality, Access, and Evaluation") OR ("Health Care Cost*") OR ("Cost Saving*") OR (“cost benefit*”)
12/20/12 PsycInfo= **24,082**

OR Search Set #1: **Other Search Terms**
((DE "Disease Management" OR DE "Quality of Care" OR DE "Health Care Utilization" OR DE "Health Care Economics" OR DE "Health Care Delivery" OR DE "Managed Care" OR DE "Telemedicine" OR DE "Quality of Services" OR DE "Health Care Costs" OR DE "Clinical Practice" OR DE "Costs and Cost Analysis" OR DE "Budgets" OR DE "Health Care Costs" OR DE "Health Care Policy" OR DE "Health Care Reform" OR DE "Health Care Administration" OR DE "Hospital Administration" OR DE "Health Care Services" OR DE "Continuum of Care" OR DE "Primary Health Care" OR DE "Treatment Effectiveness Evaluation" OR DE "Cost Containment" OR DE "Prospective Studies"))
12/20/12 PsycInfo= **33,902**

**2 Electronic Health Record/EMR/Patient Data Collection/Clinical Practice**
AB ("Electronic Health Record*") OR EHR* OR (“electronic health record*”) OR (“electronic health information”) OR (“electronic medical record*”) OR EMR* OR (“EHR implementation”) OR (*chronic disease management system*”) OR (CDMS) OR (“Medical Order Entry System*”) OR ("Medical Records Systems Computerized") OR ("Patient Data Collection") OR (DE "Clinical Practice") OR (DE "Client Records") OR (DE "Health Screening") OR (DE "Medical Diagnosis") OR (DE "Disease Management") OR (DE "Decision Support Systems") OR ("Patient Identification System*") OR (“personal health record*”) OR (CDSS) OR ("Decision Support Systems Clinical") OR (“Decision Support Techniques") OR (“Decision Support Systems Management”) OR (“clinical decision support”) OR (“health care decision support”) OR (“healthcare decision support”) OR (“health information technolog*”) OR (“hospital information system*”) OR (DE "Information Technology") OR (“medical decision-making”) OR (“medical decision making”)
12/20/12 PsycInfo= **263,803**

**3 Evidence Based Practice/EBM/Guidelines #1 SMART TEXT**
(((((((MM "Treatment Effectiveness Evaluation")) OR (MM "Treatment Guidelines" OR MM "Treatment Outcomes" OR MM "Psychotherapeutic Outcomes" OR MM "Treatment Planning" OR MM "Discharge Planning")) OR (MM "Decision Making" OR MM "Decision Support Systems")) OR (MM "Medical Model")) OR (MM "Evidence Based Practice")) OR (DE "Best Practices" OR MM "Health Care Delivery")) OR (MM "Professional Standards" OR MM "Quality of Services")
**Limit fields: --human, 1996-10/31/2012, smart text searching and Document Source: All Journals, Peer Reviewed Journals, Dissertation Abstracts, Electronic Collections, Reviews**
**Hits = 65,003**

**3 Evidence Based Practice/EBM/Guidelines #2 Boolean**
(((((((MM "Treatment Effectiveness Evaluation")) OR (MM "Treatment Guidelines" OR MM "Treatment Outcomes" OR MM "Treatment Planning" OR (MM "Decision Making" OR MM "Decision Support Systems")) OR (MM "Medical Model")) OR (MM "Evidence Based Practice")) OR (DE "Best Practices" OR MM "Health Care Delivery")) OR (MM "Professional Standards" OR MM "Quality of Services")
**Limit fields: --human, 1996-10/31/2012, Boolean searching = 72,547**

**4 E-Prescribing/Clinical Pharmacy**
("Electronic Prescribing") OR ("electronic prescription*") OR ("electronic prescribing") OR ("patient order entry system*") OR ("e-prescription*") OR ("e-prescribing") OR ("medication system*") OR ("clinical pharmacy information service*") OR (“computerized physician order entry system*”) OR (“computerized patient order entry system*”) OR CPOE OR ("computerized prescribing") OR ("computerized prescription*") OR ("drug monitoring") OR ("adverse drug event*") OR ("medication error*") OR ("drug delivery*") OR ("Prescriptive Authority") OR ("Prescribing Pattern*") OR ("Clinical Pharmacy Information System*") OR ("Decision Support Systems Clinical") OR ("Pharmacy Service") OR ("Pharmacy Administration") OR ("Insurance Pharmaceutical Services") OR ("Drug Delivery Systems" OR ("Clinical Pharmacy Information System*") OR PDSS OR (“Pharmacy Decision Support System”) OR (“physician prescribing pattern*” OR (MM "Drug Therapy*”)
12/21/12 PsycInfo= **65,811**

**5 Patient Satisfaction**
((MM "Quality of Services") OR (DE "Quality of Care") OR (DE "Best Practices") OR (DE "Consumer Attitudes") OR (DE "Consumer Satisfaction") OR (DE "Health Care Delivery") OR ("patient satisfaction with healthcare delivery*) OR ("patient satisfaction with health care delivery*))
12/21/12 PsycInfo= **2,868**

**6 PubMed Topic Specific Queries**
(health information exchange OR hie OR regional health information organization OR electronic health data OR personal health data OR personal health record* OR health **records, personal** OR personal health record OR ehealth OR e-health OR e-health OR medical informatics application* OR medical records system* OR medical records

**system, computerized** OR medical records system* computerized OR computerized patient medical record* OR automated medical record system OR automated medical record* system* OR computerized medical record* OR computerized patient record* OR computerized patient medical record* OR electronic health record* OR electronic health Record* OR electronic patient record* OR electronic medical record* OR electronic healthcare record* OR electronic health care record*)
12/21/12 – In PsycInfo, this search retrieves over 1,000,000 records. I wouldn't use it but it is here if you want to use it.

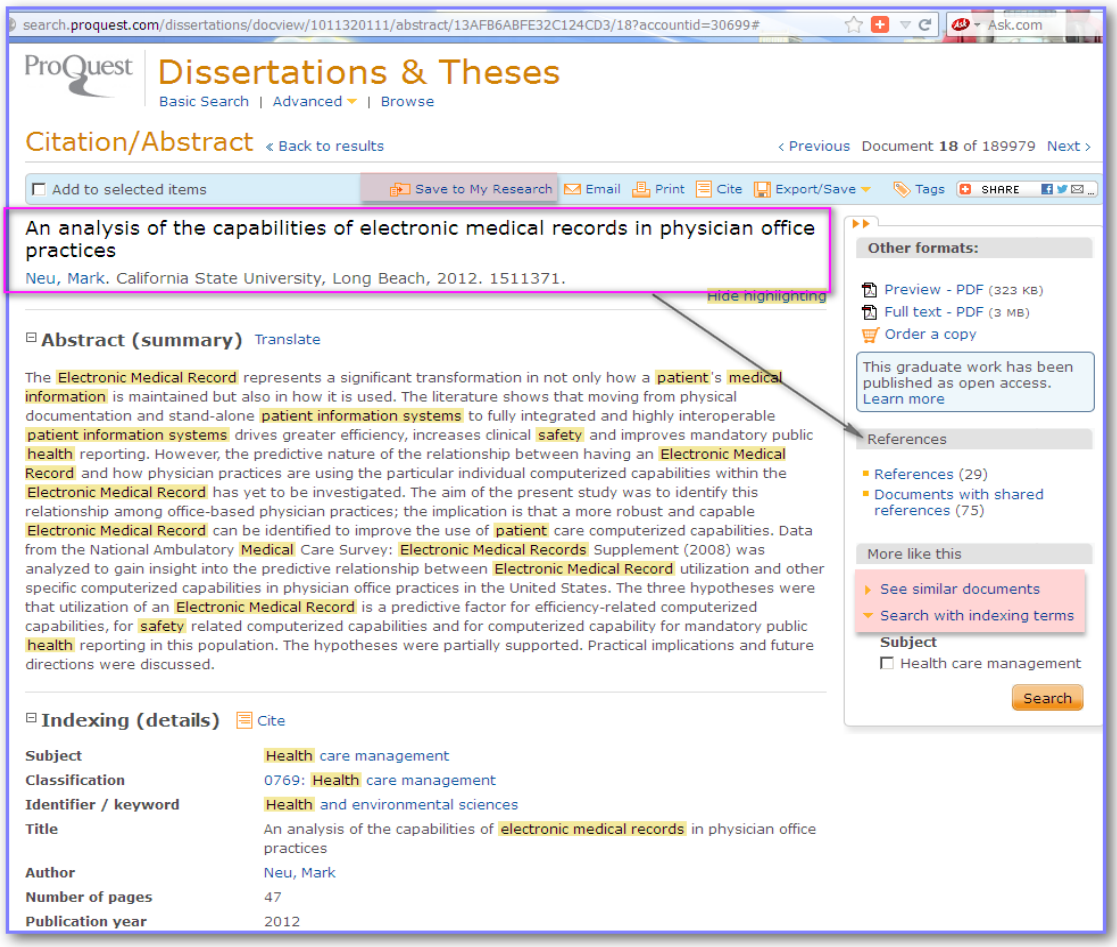
# Database:  Dissertation Abstracts International

Created on December 14 2012
This resource is so large that it is challenging to narrow down your retrievals… however, DAI has some very good and current theses.  I used search terms in the Abstract field – that is what the AB means in search strings.

Note: You must first log into your Storrs Net ID account prior to UCHC Database List Letter "D" and then clicking on Dissertation Abstracts International (DAI).  If you do not have a Net ID from Storrs, go to sign up for one at: https://netid.uconn.edu/NetIDHome/

How a citation in DAI looks:

12/13/2012 3:23:32 PM
One example of what a record from Dissertation Abstracts looks like




http://search.proquest.com/dissertations/docview/1011320111/abstract/13AFB6ABFE32C124CD3/18?accountid=30699#

**DAI Search Strings** – Remember to slide the bar on the right-hand side of the screen to *1996-2012* to limit your retrievals.  **AB** means "Abstract" Field search

**1  DAI: Cost Benefit / Quality of Health Care**

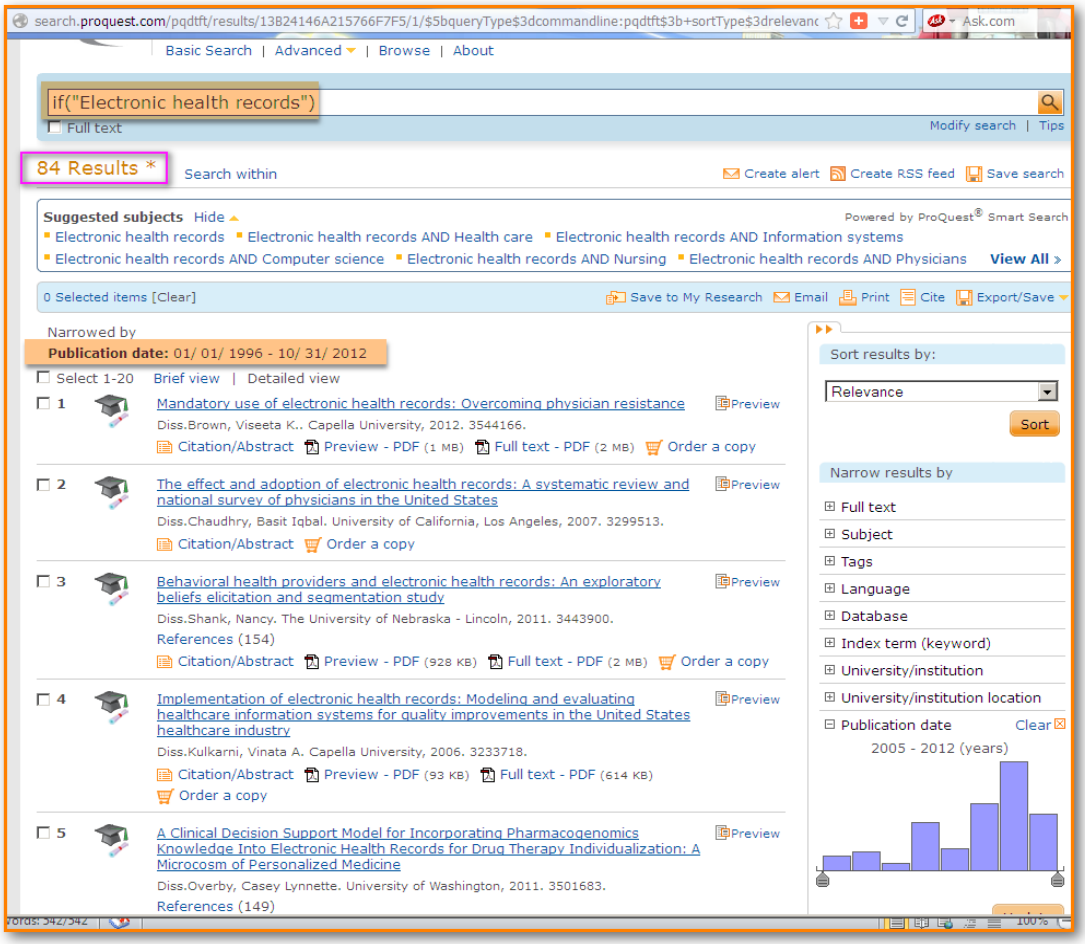
AB(("Cost-Benefit Analysis" OR "cost benefit analysis" OR "cost-effectiveness" OR "cost effectiveness" OR "hospital cost*" OR "Quality of Health Care" OR "Quality of Care" OR "Quality Assurance Health Care " OR " Outcome Assessment " OR "improved patient outcome*" OR "patient outcome*" OR " Health Care Evaluation Mechanism* " OR " Health Expenditure* " OR healthcare expenditure* OR "health care expenditure*" OR "healthcare cost*" OR "health care cost*" OR "healthcare quality improvement*" OR "health care quality improvement*" OR "quality of healthcare" OR "quality of health care" OR "Health Care Quality Access Evaluation" OR "Health Care Cost*" OR "Cost Saving*" OR "cost benefit*")) 12/21/12 DAI= **7,047**

**OR**

AB("health care quality improvement*" OR "quality of healthcare" OR "quality of health care" OR "Health Care Quality Access Evaluation" OR "Health Care Cost*" OR "Cost Saving*" OR "cost benefit*") 12/21/12 DAI= **4,500**

## 2 DAI Electronic Health Record/EHR/EMR

**if(**"Electronic health records"**)** = on 12/21/2012 there were **84 records** retrieved, see below




OR

AB((electronic health record* OR EHR OR electronic medical record* OR EMR OR electronic patient record*) OR (health information system* OR hospital information system* OR HIE OR electronic hospital record* OR medical information system*))
12/21/12 DAI= **6,042**

**3 Clinical Decision Support Systems/CDSS**
AB(clinical decision-support system* OR CDSS OR clinical information system* OR decision support system* OR medical decision making OR medical decision-support system*)
12/21/12 DAI= **9,602**

**4 Preventive Health Care**
AB(preventive health service* OR preventive medicine OR disease prevention OR preventive health care OR preventive healthcare))
12/21/12 DAI= **4,398**

**5 Quality of Health Care/Patient Outcomes**
AB("Health Care Delivery Integrated" OR "Outcome* Health Care" OR "Healthcare Outcome*" OR "Patient Outcome*" OR Health Services Needs and Demand" OR "Adverse Health Care Event*" OR "Health Care Delivery" OR "Outcome Assessment" OR "Patient Centered Care" OR "Continuity of Patient Care" OR "Progressive Patient Care" OR "Quality of Care Research" OR “Quality of health care" OR “quality of healthcare” OR “patient satisfaction” OR “improved patient outcome*” OR “consumer satisfaction” OR "patient safety" OR "Continuity of Patient Care")
12/21/12 DAI= **935**

**6 E-Prescribing/POE/DrugTherapies**
AB("Electronic Prescribing" OR "electronic prescription*" OR "patient order entry system*"OR "e-prescription*" OR "e-prescribing" OR “computerized patient order entry system*” OR “computerized physician order entry system*” OR CPOE* OR "medication system*" OR "clinical pharmacy information service*" OR "hospital information service*""computerized prescribing" OR "computerized prescription*" OR "drug monitoring" OR "adverse drug event*" OR "medication error*" OR "drug delivery*" OR "Prescriptive Authority" OR "Prescribing Pattern*" OR "Clinical Pharmacy Information System*" OR "Pharmacy Service" OR "Pharmacy Administration" OR "Insurance Pharmaceutical Services" OR "Drug Delivery System*" OR "Clinical Pharmacy Information System*" OR PDSS OR “Pharmacy Decision Support System” OR “physician prescribing pattern*” OR "Drug Therap*" OR "patient medication*")
12/21/12 DAI= **3,898**

Also check out: **ROAR: Registry of Open Access Repositories** Can search for worldwide open access archives, and specify “Theses” as document type
http://roar.eprints.org/view/type/theses.html

# Database: Google Scholar

Created on December 14 2012

**1 Cost Benefit/Quality of Health Care/Healthcare Costs/Outcomes**
"Quality Assurance Health Care" OR "Outcome Assessment Health Care" OR "*improved* patient outcome*" OR "patient outcome*" OR "Health Care Evaluation" OR "healthcare effectiveness" OR "health care effectiveness"
**or**
"Quality Assurance Health Care" OR "Outcome Assessment Health Care" OR "improves patient outcome*" OR "patient outcome*" OR "Health Care Evaluation" OR "healthcare effectiveness" OR "health care effectiveness"

**OR**
**((**"Health Care Delivery Integrated" OR "Outcomes Health Care" OR "Health Services Needs and Demand" OR "Adverse Health Care Event*" OR "Health Care Delivery" OR "Outcome Assessment" OR "Patient Centered Care" OR "Continuity of Patient Care" OR "Progressive Patient Care" OR "Quality of Care Research" OR "Quality of Care Research" OR "Quality of health care" OR "quality of healthcare" OR "patient satisfaction" OR "improved patient outcome*" OR "consumer satisfaction" OR patient safety OR "Continuity of Patient Care"**))**
**OR**
(("Cost-Benefit Analysis" OR "cost benefit analysis" OR "cost-effectiveness" OR "cost effectiveness" OR "hospital cost*" OR "Quality of Health Care" OR "Quality of Care" OR "Quality Assurance Health Care " OR " Outcome Assessment " OR "improved patient outcome*" OR "patient outcome*" OR " Health Care Evaluation Mechanism* " OR " Health Expenditure* " OR healthcare expenditure* OR "health care expenditure*" OR "healthcare cost*" OR "health care cost*" OR "healthcare quality improvement*" OR "health care quality improvement*" OR "quality of healthcare" OR "quality of health care" OR "Health Care Quality Access Evaluation" OR "Health Care Cost*" OR "Cost Saving*" OR "cost benefit*"))

**2 E-Prescribing/POE**
**((**"Electronic Prescribing" OR "Electronic-prescribing system" OR Clinical Pharmacy Information System*" OR "electronic prescription*" OR "electronic prescribing" OR "e-prescription*" OR "e-prescribing" OR "medication system*" OR "clinical pharmacy information service*" OR "computerized physician order entry system*" OR CPOE OR "computerized patient order entry system*" OR "physician prescribing pattern*" OR "drug delivery system*" OR PDSS OR "Pharmacy Decision Support System"**))**

**OR**
**((**Electronic Prescribing" OR "electronic prescription*" OR "electronic prescribing" OR "patient order entry system*" OR "e-prescription*" OR "e-prescribing" OR "computerized patient order entry system*" OR "computerized physician order entry system*" OR CPOE OR "medication system*" OR "clinical pharmacy information service*" OR "computerized prescribing" OR "computerized prescription*" OR "drug

monitoring" OR "adverse drug event*" OR "medication error*" OR "drug delivery*" OR "Prescriptive Authority" OR "Prescribing Pattern*" OR "Clinical Pharmacy Information System*" OR "Pharmacy Service" OR "Pharmacy Administration" OR "Insurance Pharmaceutical Services" OR "Drug Delivery System*" OR "Clinical Pharmacy Information System*" OR “physician prescribing pattern*” OR "Drug Therap*"**))**

**3 Preventive Health Care**
**(preventive health service* OR preventive medicine OR disease prevention OR preventive health care OR preventive healthcare)**

**((**preventive health service* OR preventive medicine OR disease prevention OR preventive health care OR preventive healthcare**))**
**OR**
http://scholar.google.com/scholar?q=preventive+health+service*+OR+preventive+medicine+OR+disease+prevention+OR+preventive+health+care+OR+preventive+healthcare&btnG=&hl=en&as_sdt=1%2C7&as_ylo=1996&as_yhi=2012
**4 Electronic Health Record/EHR/EMR**
**((**electronic health record* OR EHR OR electronic medical record* OR EMR OR electronic patient record*) OR (hospital information system* OR HIE OR computerized hospital record*) OR (electronic medical record* AND patient safety) OR (EHR and meaningful use) OR (health information system* OR medical information system**))**

**5 Clinical Decision Support Systems/CDSS**
**((**clinical decision-support system* OR CDSS OR clinical information system* OR decision support system* OR medical decision making OR medical decision-support system***))**

**6 Preventive Health Care**
**((**preventive health service* OR preventive medicine OR disease prevention OR preventive health care OR preventive healthcare**))**