

The Value of Co-Citation Analysis for Understanding a Field's Intellectual Structure: An Application to Healthcare Information Technology (HIT) Research Completed Research Paper

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Abstract

In this paper, we introduce the technique of co-citation analysis from the field of Library and Information Science. In addition to describing how this analytic method has been employed in other fields, we explain how document co-citation analysis differs from author co-citation analysis in terms of precision. We pose three questions for our empirical study of HIT research and describe our document co-citation analysis of citations to HIT research appearing in 20 leading IS journals and eight leading general medicine journals from 2000 to 2010. We performed co-citation analysis separately for published research in IS and medicine, identifying nine and eight subfields of HIT research, respectively. We describe the specific subfields in each domain and list sample papers corresponding to them. Finally, we identify the common attributes of older studies that cause them to be co-cited often, including how such attributes differ between IS vs. medicine.

Keywords

Co-citation analysis, document co-citation analysis, healthcare IT, medical informatics, scientometrics.

Introduction

It is widely recognized that the information systems (IS) field draws most of its theoretical foundations from other disciplines, such as economics, psychology, sociology, and computer science (Avgerou 2000). This awareness is captured in the frequent use of terms such as “reference disciplines” or “contributing disciplines” to refer to the fields from which IS scholars borrow their theoretical grounding. Perhaps less known is that many of the analytic techniques employed by IS scholars are ones originating in these fields – and others. Ironically, one field that IS researchers infrequently draw upon for method contributions is our “sister discipline” of information science (which was historically named, “Library Science,” although the title of “Information Science” or “Library and Information Science” are the current terms). In fact, to many non-academic practitioners and even academics from non-business disciplines, the fields of IS and information science appear to be synonymous.

Not only do IS researchers infrequently draw upon analytic methods and theories originating within information science (Ellis, Allen & Wilson 1999), but when IS scholars *do* employ information science methods, they often choose the most rudimentary, simplistic methods. While the terms “bibliometrics” and “scientometrics” have been mentioned more often in the IS field during the past decade (Straub 2006), especially since *MIS Quarterly* recently ceased its prohibition on publishing papers in this genre (Straub 2008), a cursory review of papers labeled as “scientometric” in the IS field would reveal that typically these papers are simply descriptive lists of the “most prolific authors” (Athey & Plotnicki 2000;

Huang & His 2005) “most frequently-cited papers,” (Lowry et al 2007), or “leading institutions” that contribute to the IS field (Eom 1994; Eom & Lee 1993; Holsapple et al. 1995). We regard such papers as descriptive lists that tally and sort numbers corresponding to publications and citations – without providing much analysis about *why* specific patterns of research productivity or institutional prestige exist.

As an established discipline, information sciences has much more to contribute to IS research – or to other business, social science, and physical science fields – than the use of simple rank-ordered lists of the number of author’s publications or citations to them. One technique that is sometimes used in the IS field (but much more commonly used in other business and social science disciplines) is co-citation analysis to identify the “intellectual structure” of a field of study. Although we can identify several instances in which co-citation analysis has been used in the IS discipline, the vast majority of these studies are either very old studies of the intellectual structure of IS when it was first emerging in the 1970s and 1980s (Culnan 1986; Culnan 1987); or more recent, but much narrower analyses of specific topics within the IS field, such as decision support systems (DSS) (Eom 1996), the Technology Acceptance Model (Hsiao & Yang 2011), or virtual teams (Raghuram et al 2010). What is perhaps overlooked by these two types of co-citation analyses (older, holistic studies and new, but narrower studies) is a broader recognition among IS researchers of the value of co-citation analysis to IS researchers, in general.

While there is some evidence that discrete pockets of IS researchers are aware of co-citation analysis and its potential value to IS research – such as several papers published by Sridhar Nerur of the University of Texas at Arlington (Nerur et al. 2000; Raghupathi & Nerur 2008; Sircar, Nerur et al. 2001), we believe that co-citation analysis is either unfamiliar or poorly understood by most IS researchers. In this paper, we introduce this technique to a broader population of IS researchers, identify different variants of co-citation analysis that are possible, and show how co-citation analysis can be employed to understand an important, interdisciplinary topic of healthcare information technology (HIT) research – which is often labeled as “medical informatics” or “health informatics” in fields such as health administration and medicine. In addition to introducing co-citation analysis to IS scholars, we provide an example using papers about HIT from eight leading medical journals and from 20 leading IS journals on the topic of HIT to show how this approach can be used to define the intellectual structure of this important area.

Literature Review

Unlike its more simplistic cousin of “citation analysis” (which simply counts and sorts data regarding the number of papers published or number of citations to each paper), co-citation analysis performs complex mathematical calculations on raw citation data to identify the underlying “intellectual structure” of a given discipline (Small 1973). Starting with raw citation data about which subsequent papers have cited which earlier papers, co-citation analysis identifies how often subsequent papers cite the same pairs of earlier studies. It then transforms these raw citation data into matrices that identify the macro-level pattern involving which pairs of earlier papers are often cited together vs which pairs of papers are *never* or rarely co-cited together.

Based on the underlying assumption that the reason that a subsequent study cites two earlier studies is because all three papers deal with similar topics, co-citation analysis is able to detect the underlying “intellectual structure” of a domain of research, however broadly or narrowly defined. Some uses of co-citation analysis in IS have focused on the entire IS field, albeit at an early point in time (Culnan 1986), while other studies analyzed just the papers published in a given journal (e.g., Tengyue et al. 2011) or papers related to a specific theory, such as the Technology Acceptance Model (e.g., Hsiao & Yang 2011).

While the assumption underlying co-citation analysis is that earlier papers are co-cited because they focus on the same topic, there may be other reasons why papers are often cited together: it could be that the underlying theory and/or research methods employed are the same, because the industry context is the same as prior studies in the industry, or because the technology user/adopter population is the same (e.g., managers, students, etc.). This means that researchers interpreting data from co-citation analysis must

be sensitive to the various attributes that cause pairs of papers to be cited together – whether based on similar topics, theories, research methods, adopter populations, or other attributes altogether.

Our goal in this paper is to introduce co-citation analysis to a large number of IS researchers to identify its relative advantages and disadvantages vis-à-vis other approaches for reviewing a large body of literature on a given topic, and to illustrate its application to the growing topic of healthcare IT research.

There are three major variants of co-citation analysis, with additional, minor variations for each. The major variations are whether the unit of analysis (a) the “author” (thus, the label – author co-citation analysis), (b) the published paper or “document” (thus, the label document co-citation analysis), or (c) the journal in which the cited studies appeared. Of the three major variants, the first one – author co-citation analysis – is most common and the last one (journal co-citation analysis) is least common. With author co-citation analysis, the technique seeks to identify which two prior authors are frequently co-cited together, which then yields a classification of several groups of authors – from which a set of topics can be identified (Culnan 1986). Although author co-citation analysis has been used more often in the IS field than document co-citation analysis (which we describe next), one limitation of author co-citation analysis is that it assumes that an author’s research focuses on the same topic throughout his or her career.

Using an example from the IS field, an author co-citation analysis of a leading IS scholars such as V. Sambamurthy and Rick Watson would assume that their research has consistently been on the same topic (presumably Group Decision Support Systems, or GDSS for both authors). While such an assumption may appear reasonable, since this was the topic area in which both of these leading authors *began* their careers, in the second and third decades of their research careers, they branched out into several other topics unrelated to GDSS or IT usage. Unfortunately, author co-citation analysis would take a rather coarse view of each author as largely focusing on a single topic throughout his or her career, which might distort the interpretation of results.

Document Cocitation Analysis. Document co-citation analysis focuses on the “document” as being the unit of analysis. This means that different papers published by the same author have the opportunity to load separately from each other – but such papers can load with similar papers on the same topic. Using the example from above, we know that V. Sambamurthy and Rick Watson published many earlier papers on GDSS, but then they moved on to publish on other topics such as IT governance (V. Sambamurthy) and “green IS” (Rick Watson), respectively. With document co-citation analysis, the papers by these authors on different topics would be treated separately in the analysis – yielding a more fine-grained analysis of co-citation details, and a more precise interpretation of subfields within IS research. While we believe that the general technique of co-citation analysis is unknown or poorly understood by many IS researchers, in particular, we believe that “document co-citation itself” is even *less* well-known by IS scholars, because it has been infrequently used in the IS field, to the best of our knowledge.

We searched to find other studies that employed co-citation analysis in the IS literature as well as in closely-related fields (e.g., computer science, information science, etc.). While we lack space here to list all of the co-citation analyses that we identified, we first mention some variations that are possible *within* each of the major forms (author co-citation analysis and document co-citation analysis) described above.

Some co-citation analysis papers that we found begin with a baseline set of papers in a given field and analyze the “references” *within* those papers (i.e., the older references that appear in the baseline set of papers) whereas other studies start with a baseline set of papers and then gather data about *subsequent* citations to those papers – based on citations tracked by “Web of Science” (formerly known as *Science Citation Index and Social Science Citation Index*). Both approaches (i.e., analysis of references and analysis of citations) are frequently used in the information science discipline and both methods are regarded as useful. We could not find any mention of one approach being superior to the other.

Another variation is whether just the first author of the cited paper is analyzed or all authors (Eom 2008; Zhao & Strotman 2008). Using an example from the IS field, if we consider the seminal paper introducing the “IS Success Model” by William DeLone and Ephraim McLean, for the first author analysis, just

William DeLone would be included in the co-citation analysis (but Ephraim McLean would be ignored). Again, both approaches – first author vs. all author co-citation – are used in information sciences, as well as in the IS field (Eom 2008). According to recent comparisons of both approaches, the weakness of using just the first author in co-citation analysis is more pronounced in disciplines with high levels of coauthoring (e.g., medicine, bioscience, physical sciences) than in fields with low levels of coauthoring (i.e., the humanities). The IS field falls in between these two extremes, with typically two to four authors.

A third possible variation is whether the citation data is captured from a proprietary citation database (such as ISI/Reuters' Web of Science) or from a freely-available database, Google Scholar. We label this as a "possible" variation, because we were unable to locate any published studies that relied on Google Scholar as the citation data source for performing co-citation analysis. All published studies using co-citation analysis that we located used ISI/Reuters' Web of Science database – which is much more restrictive than Google Scholar as a citation source. By restrictive, we mean that Web of Science only tracks citations to well-established, high-quality, elite academic journals whose language of publication is English. In contrast to Google Scholar, Web of Science does not track citations coming from conference proceedings, working papers, dissertations, or chapters in edited, scholarly books. It is possible that, in the future, more authors performing co-citation analyses will turn to Google Scholar as their underlying citation source. As of 2014, this has not yet occurred in practice.

Returning to our initial description of the three major variants of co-citation analysis (author, document, and journal), most studies in the IS literature have employed author co-citation analysis. In our searches, we found just one *journal* paper that employed document co-citation analysis to analyze studies from the IS field: a review of the Technology Acceptance Model (TAM) (Hsiao & Yang 2011), and no papers that employed journal co-citation analysis. We are aware of some IS *conference* papers that used document co-citation analysis to analyze other IS topics – such as papers on the topic of "IT strategic alignment" (Renaud et al. 2012) or papers published in *Journal of MIS* (Tengyue et al 2011). In other business and social science disciplines, we found many papers using document cocitation analysis, such as operations management (Charvet et al. 2008; Pilkington & Meredith 2009) and strategic management (Gregoire et al. 2006; Ramos-Rodríguez & Ruíz-Navarro 2004).

Author co-citation analysis has been more visible in IS and computer science research than document co-citation analysis. As described above, the former approach aggregates all citations to an author's publications, without regard for differences in the actual topics that constitute his or her work. Given that many leading authors have careers spanning three or four decades, the author co-citation analysis method assumes that an author works on the same problem domain throughout his or her career. The results of author co-citation analysis can be difficult to interpret when this assumption is not met (i.e., when an author works on diverse topics over her career). In contrast, the more detailed method of document co-citation analysis recognizes that the same author may publish on different topics, and thus, it tracks citations to different papers separately. The output resulting from document co-citation is a more fine-grained analysis of topics, taking into account possible changes in authors' interests over their careers.

The earliest author co-citation papers in the IS literature appeared in the 1980s – reviewing the early history of the IS field (Culnan 1986; Culnan 1987). In this regard, such early studies in the IS field paralleled those Library and Information Science – from which the methods were borrowed. Aside from these initial co-citation analyses by Mary Culnan, subsequent use of the method in the IS discipline tended to focus on specific sub-topics, such as decision support systems (Eom 1996; Eom & Farris 1996), information retrieval (Ding et al 1999), and software development methods (Sircar, Nerur et al. 2001), or else specific theories – such as the Technology Acceptance Model (Hsiao & Yang 2011).

Research on Healthcare IT. The only paper to date that has provided a comprehensive review of the HIT domain by Chiasson & Davidson (2004), published a decade ago in *Information and Organization*. This paper is not a co-citation analysis, but rather, it employs a structured approach to reviewing papers about HIT published in IS journals from 1985 to 2003. To our knowledge, this is the only comprehensive review of the HIT literature published in IS journals. Focusing on health informatics niche journals, Raghupathi

and Nerur published two co-citation analysis studies identifying the intellectual structure of health and medical informatics research in 2008 and 2010. In 2008, they published an author co-citation analysis based on papers published from 1998-2006 by researchers serving on the editorial boards of five health informatics journals: *International Journal of Electronic Healthcare*, *International Journal of Healthcare Information, Systems & Informatics*, *International Journal of Medical Informatics*, *Journal of Medical Internet Research*, and *Medical Informatics and the Internet in Medicine*. Using factor analysis, cluster analysis, and multidimensional scaling, Raghupathi & Nerur (2008) identified 13 factors representing various subfields of health informatics (e.g., HIS evaluation, e-health, mobile computing, telemedicine, clinical Decision Support Systems, and others).

Two years later, in 2010, Raghupathi and Nerur published another study in *International Journal of Healthcare Information Systems and Informatics* (Raghupathi & Nerur, 2010), expanding on their first paper by analyzing all papers published by scholars who served on the editorial boards of eight journals. In the later paper, they expanded the list of journals from which they identified editorial board members by adding three more – primarily technical – journals: *IEEE Transactions on Information Technology in Biomedicine*, *Journal of Biomedical Informatics* and *Journal of the American Medical Informatics Association*. Given that the expanded set of journals included two bioengineering or bioinformatics journals, the overall set of topics resulting from their later author co-citation was very different (based on eight journals) than the earlier study (based on five journals). Of the total of 14 topic areas identified in their later study were many subfields of medical informatics that were absent from their earlier results: ontology and medical terminology, bioinformatics, artificial intelligence, natural language processing, computational genomics, bioinformatics, user interface design, and others.

While we seek to use methods similar to those employed by Raghupathi & Nerur (2008), we focus on HIT research published in mainstream IS journals and in medical journals. In our study, we chose the more precise but less common technique, document co-citation analysis, instead of author co-citation analysis. Because we recognized that the same author may work on different topics over the course of his or her career, we believe that the extra precision – and larger dataset size – required for document co-citation analysis will yield more detailed insights about research topics. In our study, we seek to understand what specific subtopics exist within HIT research in IS journals and in medical journals.

Healthcare IT has become an important topic within the IS field, especially given the priorities of the U.S. Obama administration, its Affordable Care Act, and large amounts of funding for health IT research. While we lack sufficient space to review all prior studies of HIT, in seeking to understand the techniques that IS researchers employ to review prior research, we note that IS scholars use few of the advanced analytic methods for reviewing prior research that are employed in medicine. In medicine and in medical informatics journals, there are dozens of review papers that employ sophisticated techniques like meta-analysis (Eysenbach et al. 2008; Portnoy et al 2008) and co-citation analysis (Andrews 2003; Morris & McCain 1998; Shuemie et al 2009). Of course there are also dozens of structured reviews as well – which are labeled “systematic reviews” in medicine (Black et al 2011; Häyrinen et al. 2008; Orr & Karsh 2009).

In this paper, we seek to apply co-citation analysis to identify the subtopics within the domain of HIT research (as it is called in IS journals) or medical informatics (as it is called in medicine). For instance, by conducting document co-citation analysis, we expect to be able to identify different streams of research – either based on different types of IT artifacts (i.e., electronic patient records, hospital financial systems, nursing management systems), different research methods (ethnography, surveys, and archival data), or based on the underlying theories employed in research (i.e., Technology Acceptance Model, Actor-Network Theory, Institutional Theory). Given our general objectives, we pose three questions:

Question 1: What topics can we identify using co-citation analysis for HIT research in IS journals?

Question 2: What topics can we identify using co-citation analysis for medical informatics research in medical journals?

Question 3: Are the topics similar between the two fields – IS vs. medicine?

Research Methods

We identified all papers published in the two fields – IS and medicine – on the topic of healthcare IT, based on the following criteria. For IS journals, we identified nearly 25 leading IS journals, for which we searched for all papers published from 2000 to 2010.¹ For the medical journals, we limited our search to the eight general medical journals with the highest “impact factor” metrics listed in ISI/Reuter’s online database, Web of Science. These are *Journal of the American Medical Association (JAMA)*, *New England Journal of Medicine (NEJM)*, *The Lancet*, *Annals of Internal Medicine*, *British Medical Journal*, *Archives of Internal Medicine*, *Canadian Medical Association Journal* and *PLoS Medicine*.

For the IS journals we used the Web of Science database to search for the following seven terms in the paper’s title, abstract, or keywords: doctor, healthcare, hospital, medical, medicine, nurse, and nursing. In the medical journals, we performed a similar search on five terms appearing in the paper’s title, abstract or keywords – specifically computer, computing, informatics, system, and technology.

After retrieving papers with these terms appearing in the title, abstract, or keywords from Web of Science, we performed an initial screening to ensure that the papers focused on healthcare IT. We excluded a small number of papers, where the specific terms were not related to the study’s focus (i.e., where “medicine” was mentioned in the abstract as a possible context for the technology described in the paper, but where medicine did not subsequently appear again in the paper). Based on the results of our initial analysis, we made some revisions to our search terms. For example, by comparing our results to those of Davidson & Chiasson (2004), we realized that our search of the term “healthcare” (one word) had excluded papers with alternate spellings: health-care or health care (two words). We also recognized that we had overlooked papers with the words “hospital” or “clinical” in their title or keywords, so we revised and repeated our searches with these changes. Based on our search of papers published from 2000 to 2010 inclusive, we identified 103 papers in IS journals that met our criteria as being published from 2000 to 2010 in twenty leading IS journals on the topic of HIT. We conducted a similar screening of papers in medical journals – finding thousands of papers with the term “computer” in the paper’s abstract, merely because the study mentioned a clinical study where computer-generated randomization was used to assign subjects to control and experimental groups. We manually screened out papers in these journals where this was the only context in which the term “computer” appeared. After doing so, we were left with a total of 156 papers focusing on medical informatics in eight general medical journals.

We restricted our search to papers published before 2011, since our goal was to analyze *subsequent* citations to these papers. Given the long review cycles at IS journals, we knew that published IS papers accrue few citations on Web of Science during the first four years after publication. Based on our own prior work analyzing citation data, we also knew that the annual rate of citations to papers published in IS journals do not peak until six-to-seven years after the year of publication.

For each of the retrieved papers (103 papers in IS journals; 156 papers in medical journals), we created a spreadsheet showing basic bibliographic details of the study: title, author names, journal title, publication year, and the number of *subsequent* citations to that paper. We then coded the same detailed information for all of the subsequent citations to the baseline set of papers. In order to perform the co-citation analysis we analyzed the data about the frequency with which two earlier papers are cited by a subsequent paper. As is standard in such co-citation analyses, we identified a cut-off point for how many of the 103

¹ The IS journals are: ACM Computing Surveys, Communications of the ACM, Decision Support Systems, European Journal of Information Systems, Information & Management, Information and Organization, Information Systems Journal, Information Systems Research, Journal of the AIS, Journal of Management Information Systems, MIS Quarterly, IEEE Transactions on Engineering Management, Information Technology & People, Journal of Information Technology, Journal of Organization Computing and eCommerce, Journal of Strategic Information Systems.

papers we would analyze (since performing co-citation analysis to identify all citations to all 103 IS paper would require that we create a 103 x 103 matrix – that is, a matrix consisting of 10,609 individual cells, where most of the cells would have zero values (indicating papers that were *never* cited together). Since the goal of co-citation analysis is to analyze papers that are frequently co-cited together, we limited our analysis to just those papers in IS journals and in medical journals that had been cited ten or more times in Web of Science. Using this threshold of ten citations, we retained 77 papers from IS journals and also the same number of papers (77) from medical journals. With the help of a dedicated research assistant, we coded the detailed citation data for 2,625 citations to the 77 articles in IS journals (i.e., an average of about 36 citations per paper); we also coded 8,537 citations to the 72 papers from medical journals (i.e., an average of 111 citations per paper).

For IS papers, we then created a 77 x 77 matrix (i.e., 77 rows and 77 columns, resulting in a matrix with 4,761 cells), with the numbers in each cell representing the number of times that the paper represented by a specific row and a specific column had been cited together. We performed a similar analysis for the 72 x 72 matrix representing the number of times that two papers from medical journals had been cited together. We then transformed these two co-citation matrices into Pearson matrices, which served as the direct input to Factor Analysis and Cluster Analysis that we performed. We conducted the latter analyses separately for the two matrices representing citations to IS papers vs citations to medical journal papers.

We used SPSS version 13.0 to perform the Factor Analysis (choosing principal components analysis with Varimax rotation). In interpreting the results from the Factor Analysis, in order to label the factors, we read not only the title of each cited paper, but also we reviewed the abstract and the authors' names. The underlying logic of co-citation analysis is that previous papers will be co-cited together if they deal with a similar topic. Thus, we sought to label each factor in the resulting Factor Analysis after reading the title and abstract of each paper. In becoming familiar with each paper we sought to identify what attributes were common across all papers that load onto a given factor – whether the common element was the technology studied, the type of adopter population, the underlying theory, or the research method (i.e., case study, archival data, etc.). By knowing which attributes were common across the papers loading on each factor, we were able to understand why these papers loaded together, and thus, label the factor.

As part of processing and interpreting the data, we identified the papers that had been co-cited most often together in the IS field; we repeated the same process to identify the papers that had been most frequently co-cited in medical journals.

Results

Table 1 and Table 2 respectively display lists of IS and medical papers that were most frequently co-cited together. Based on these lists, we observe that each pair of frequently co-cited papers shares either a similar topic (i.e., technology acceptance of HIT), a similar type of technology, or a similar theoretical perspective.² Next, we show the Factor Analysis results for papers in IS journals (Figure 1) and medical journals (Figure 2).

Table 3 lists the 9 factors extracted from papers in IS journals and 8 factors from papers in medical journals. A cursory comparison of the factors listed in both columns of Table 3 (corresponding to the factors identified in IS journals and medical journals, respectively) suggests that paper about HIT in IS journals mostly relate to IT adoption and acceptance, the business value of IT healthcare contexts (including health insurance) and online communities, while factors extracted from medical journal papers primarily focus on how IT affects patient outcomes in terms of improving healthcare quality, establishing safety alerts, minimizing errors, and enhancing doctor-patient communication. Below, we discuss the most important factors (i.e., those accounting for the largest proportion of variance) in each field.

² Our interpretation of these results benefited from reading the Abstracts of each paper – not just the title.

In the IS field, Figure 1 and Table 3 (left column) show that HIT in Organization Settings is the largest factor, explaining 23.3% of the variance. A total of 26 papers – more than one-third of all papers that we retained in our analysis – loaded in this first factor. Most of the papers loading on this factor were qualitative studies of healthcare IT in specific organizational contexts; very few quantitative, survey-based studies loaded on this first factor. For example, (Cho & Mathiassen, 2007) studied industry infrastructure in telehealth settings, and (Cho, Mathiassen, & Nilsson, 2008) used Actor Network Theory to study IT in hospitals. It is noteworthy that 89% of the papers that loaded on this factor used qualitative methods or were conceptual in nature; with just 11% quantitative papers.

We labeled the second factor (which accounted for 16.9% of the variance) as IT adoption and acceptance. A total of 17 papers loaded on this factor, with a majority being quantitative, survey-based studies. Many of these papers discussed the Technology Acceptance Model (TAM) in healthcare scenario for various types of adopters. For example, (Yi et al, 2006) and (Chau & Hu, 2002) studied IT acceptance by individual physicians; (Liu & Ma, 2005) discussed acceptance of medical records based on an application service provider model; and (Klein, 2007) studied the patient-physician portal acceptance. Many papers analyzed the antecedents of IT acceptance or resistance in hospital settings, including Lee & Shim's (2007) paper on RFID adoption, as well as a study focusing on adoption of electronic signatures (Chang et al. 2007), and a multilevel model of user resistance by Lapointe & Rivard (2005).

We labeled the third factor (which accounted for 15.6% of the variance) as Business Value of IT Investments in healthcare contexts (including health insurance). A total of 14 papers loaded on this factor. Among the specific topics were cost control and production performance in hospital and/or health insurance contexts (Menon & Lee, 2000; Ray, Muhanna, & Barney, 2005) and the value of IT integration (Ayal & Seidman, 2009). Finally, six other factors that each account for a small proportion of the variance in IS journals were: Telehealth, RFID and Mobile Technology, Online Communities, Data Integration, Healthcare Issues in Developing Countries, and the Security/Privacy in Electronic Patient Records.

As shown in Figure 2, as well as in the right-hand column of Table 3, the factors were quite different for papers published in medical journals. We labeled the largest factor resulting from our analysis "General IT in Healthcare," which explained 38.9% of the variance. There were a total of 31 papers (out of 77 total) loading on this first factor. Within this general factor, several outcomes of HIT are considered – such as the impact of IT on patient safety, relative costs and benefits, and the drivers of IT adoption in hospitals.

The second factor we identified (accounting for 14.1% of the total variance) was Healthcare Quality Issues. A total of 21 papers loaded in this factor, with most focusing on patient quality outcomes. For example, Maxson et al. (2010) considered how to help doctors make meaningful use of HIT; Baron (2007) studied how electronic health records can be used to improve quality; and Friedberg et al. (2009) investigated the effect of selected quality measures on performance.

The third factor (accounting for 8.7% of total variance) is the Availability of Internet Resources on Patients. A total of 13 papers are included this factor, such as papers dealing with the effect of the Internet on patient search behavior and communication with physicians. For example, a paper by Murray, et al. (2003) investigated the impact of Internet-based health information on the physician-patient relationship. Taking a more cynical view of the same technology, a study by Crocco et al. (2002) analyzed harm associated with the wide availability of health information on the Internet.

As with the IS journal papers, there were several other, smaller factors that each explained a small fraction of the total variance: papers dealing with using IT to minimize diagnostic errors, effect of health IT on patient outcomes, IT-based Decision Support Systems, and IT for medical safety alerts.

In reviewing the lists of papers that were most frequently co-cited together (Tables 1 and 2), we found that the papers in IS journals most frequently co-cited were ones using a similar underlying theoretical framing, rather than ones that necessarily studied the same type of healthcare IT. For example, many of the pairs of IS papers listed at the top of Table 1 are studies of physician adoption of various types of healthcare technologies, using the lens of the TAM model or the related Theory of Planned Behavior.

Many of these pairs of studies were of *different* technologies (physician order entry, electronic signatures, telemedicine, etc.), but they focused on the same adopter population (nurses) and used similar dependent variables and underlying theories. Likewise, many studies representing qualitative research dealt with the same underlying issue (i.e., user resistance) even if the actual technology examined was different.

In contrast, the frequently co-cited papers in medical journals tended to be studies of the same type of system or the same phenomenon (i.e., safety alerts, medical errors, etc.). In reviewing the medical papers most often co-cited in Table 2, we see that, in most cases, both papers focused on the same technology. This contrasts with the IS literature, where two earlier papers are often co-cited together because they use a similar theoretical framework or research method. This may be due to the fact that, in IS academic journals – but not in medical journals – the theory and the theoretical contribution are of as much importance as the empirical phenomena.

Most of the frequently co-cited papers in the IS literature tend to be related to either Factor 1 (“HIT in organizational settings”) or Factor 2 (“Healthcare IT Adoption and Acceptance”), with relatively few pairs of papers dealing with the factors in Table 3 listed below Factor 2. The only exceptions were pairs of frequently co-cited papers corresponding to Factor 3 (“Business value of IT”), which included the papers by Menon et al (2000) and Ray, et al (2005); a pair of papers corresponding to Factor 6 (“RFID and Mobile Technologies”) featuring papers by Tu et al. (2009) and by Oztekin et al (2010) concerning RFID; and a pair of papers corresponding to Factor 7 (“Online communities”), featuring papers by Paul & McDaniel (2004) and Leimeister et al (2005) focused on trust in online health communities. With the exception of these sets of papers, all other frequently co-cited papers listed in Table 1 relate to Factor 1 (“Healthcare IT in Organizational Settings”) or Factor 2 (“Healthcare IT Adoption and Acceptance”).

Discussion and Conclusions

Our paper provides the first co-citation analysis of the subject area of healthcare IT based on general IS journals, as well as general internal medicine journals. In this regard, our study contrasts with the pair of previous studies by Raghupathi and Nerur (2008, 2010), where they analyzed citations to all the papers published by members of the editorial boards of either five or eight specialized journals on medical informatics and/or bioinformatics and bioengineering. Based on our document co-citation analysis, we have shown that the topic areas corresponding to the factors extracted from our factor analysis differ between the IS field and the medical field. This is not surprising, since the two fields have different approaches to research, different standards for publication (i.e., the role of theory in IS research), and different types of readers. Perhaps more surprising is that we *did* find some common topics between the lists of factors on the left and right columns of Table 3 – namely the topic “Online Communities” in the IS literature and “Availability of Internet resources on patients” in the medical literature.

In this paper, we have presented results from our factor analysis of the healthcare IT research in both IS journals and medical journals. One limitation of our study is that we have not presented other types of analyses that are possible with co-citation analysis – such as Cluster Analysis, Multidimensional Scaling results, and Social Network Analysis results (where the nodes in the network analysis can be authors or papers). We have limited our presentation of results here to factor analysis both due to the limitations of the AMCIS conference paper format, and because the factor analysis results are the necessary first step toward interpreting the different subject areas that appear in other result formats (e.g., multidimensional scaling and Social Network Analysis). Another limitation is that we have presented our results based only on the citation data tracked by ISI/Reuters’ Web of Science database; however, we have also collected and analyzed a parallel set of citation data from Google Scholar – which capture a much larger set of citations (typically three times as large as citations tracked by Web of Science, albeit from a broader, less selective set of outlets including conference proceedings, dissertations, working papers, chapters in edited, books, as well as journals). At this time co-citation analysis studies based on Google Scholar citations are rare.

In a future study, we hope to compare the findings from our comparative analyses of citations tracked by Web of Science (as analyzed here) vs. citation tracked by Google Scholar (not presented here). Future

research may also analyze development and changes within HIT research by analyzing multiple time-periods of citation data, as Raghuram and her coauthors (2010) did for research on virtual work.

REFERENCES

- Andrews, J. E. (2003). An author co-citation analysis of medical informatics. *Journal of the Medical Library Association*, 91 (1), 47.
- Athey, S. & Plotnicki, J. (2000). An evaluation of research productivity in academic IT. *Communications of Association for Information Systems*, 3(2), 3-15.
- Avgerou, C. (2000). Information systems: what sort of science is it?. *Omega*, 28(5), 567-579.
- Ayal, M. & Seidman, A. (2009). An empirical investigation of the value of integrating enterprise IS: the case of medical imaging informatics. *Journal of Management Information Systems*, 43-68.
- Baron, R. J. (2007). Quality improvement with an electronic health record: achievable, but not automatic. *Annals of Internal Medicine*, 549-552.
- Baron, R. J. (2010). Meaningful use of health information technology is managing information. *Journal of the American Medical Association*, 304 (1), 89-90.
- Black, A. D., Car, J. P., Bokun, T. & Sheikh, A. (2011). The impact of eHealth on the quality and safety of health care: a systematic overview. *PLoS Medicine*, 8 (1).
- Chang, I., Hwang, H. G., Hung, M. C., Lin, M. & Yen, D. C. (2007). Factors affecting the adoption of electronic signature: Executives' perspective of hospital information departments. *Decision Support Systems*, 350-359.
- Charvet, F. F., Cooper, M. C. & Gardner, J. T. (2008). The intellectual structure of supply chain management: A bibliometric approach. *Journal of Business Logistics*, 29(1), 47-73.
- Chau, P. Y. & Hu, P. J. (2002). Examining a model of information technology acceptance by individual professionals: An exploratory study. *Journal of Management Information Systems*, 191-230.
- Chiasson, M. W. & Davidson, E. (2004). Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. *Information and Organization*, 14(3), 155-188.
- Cho, S. & Mathiassen, L. (2007). The role of industry infrastructure in telehealth innovations: a multi-level analysis of a telestroke program. *European Journal of Information Systems*, 738-750.
- Cho, S., Mathiassen, L. & Nilsson, A. (2008). Contextual dynamics during health information systems implementation: an event-based actor-network approach. *European Journal of Information Systems*, 614-630.
- Crocco, A. G., Villasis-Keever, M. & Jadad, A. R. (2002). Analysis of cases of harm associated with use of health information on the internet. *Journal of the American Medical Association*, 2869-2871.
- Culnan, M. J. (1986). The intellectual development of management information systems, 1972-1982: A co-citation analysis. *Management Science*, 32(2), 156-172.
- Culnan, M. J. (1987). Mapping the intellectual structure of MIS, 1980-1985: a co-citation analysis. *MIS Quarterly*, 341-353.
- DeLone, W. and McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3(1), 60-95.
- Ding, Y., Chowdhury, G. & Foo, S. (1999). Mapping the intellectual structure of information retrieval studies: An author co-citation analysis, 1987-1997. *Journal of Information Science*, 25(1), 67-78.
- Ellis, D., Allen, D. & Wilson, T. (1999). Information science and information systems: Conjoint subjects disjunct disciplines. *Journal of American Society for Information Science*, 50, 1095-1107.
- Eom, S. B. (1996). Mapping the intellectual structure of research in decision support systems through author co-citation analysis (1971-1993). *Decision Support Systems*, 16(4), 315-338.
- Eom, S. B. (2008). All author co-citation analysis and first author co-citation analysis: A comparative empirical investigation. *Journal of Informetrics*, 2, 53-64.
- Eom, S. B. & Farris, R. (1996). The contributions of organizational science to the development of DSS research subspecialties. *Journal of American Society for Information Science*, 47(12), 941-952.
- Eom, S. B. & Lee, S. M. (1993). Leading US universities and most influential contributors in decision support systems research (1971-1989) a citation analysis. *Decision Support Systems*, 9(3), 237-244.
- Eysenbach, G., Powell, J., Kuss, O. & Sa, E. R. (2002). Empirical studies assessing the quality of health information for consumers on the worldwide web. *Journal of the American Medical Association*, 287, 2691-2700.

- Friedberg, M. W., Coltin, K. L., Safran, D., Dresser, M., Zaslavsky, A. & Schneider, E. (2009). Associations between structural capabilities of primary care practices and performance on selected quality measures. *Annals of Internal Medicine*, 456-463.
- Gregoire, D., Noel, M. X., Déry, R. & Béchar, J. P. (2006). Is There Conceptual Convergence in Entrepreneurship Research? A Co-Citation Analysis of Frontiers of Entrepreneurship Research, 1981-2004, *Frontiers of Entrepreneurship Research*, 30(3), 333-373.
- Häyrinen, K., Saranto, K. & Nykänen, P. (2008). Definition, structure, content, use and impacts of electronic health records: a review of the research literature. *International Journal of Medical Informatics*, 77 (5), 291-304.
- Holsapple, C. W., Johnson, L. E., Manakyan, H. & Tanner, J. (1994). Business computing research journals: A normalized citation analysis. *Journal of Management Information Systems*, 11, 131-140.
- Hsiao, C. H. & Yang, C. (2011). The intellectual development of the technology acceptance model: A citation analysis. *International Journal of Information Management*, 31(2), 128-136.
- Huang, H. H. & Hsu, J. S. C. (2005). An evaluation of publication productivity in information systems: 1999 to 2003. *Communications of Association for Information Systems*, 15, 555-564.
- Klein, R. (2007). An empirical examination of patient-physician portal acceptance. *European Journal of Information Systems*, 751-760.
- Lapointe, L. & Rivard, S. (2005). A multilevel model of resistance to information technology implementation. *MIS Quarterly*, 461-491.
- Lee, C. P. & Shim, J. P. (2007). An exploratory study of radio frequency identification (RFID) adoption in the healthcare industry. *European Journal of Information Systems*, 712-724.
- Liu, L. & Ma, Q. (2005). The impact of service level on the acceptance of application service oriented medical records. *Information & Management*, 1121-1135.
- Lowry, P. B., Karuga, G. & Richardson, V. J. (2007). Assessing leading institutions, faculty, and articles in premier IS research journals. *Communications of Association for Information Systems*, 20, 142-203.
- Maxson, E., Jain, S., Kendall, M., Mostashari, F. & Blumenthal, D. (2010). The regional extension center program: helping physicians meaningfully use health information technology. *Annals of Internal Medicine*, 666-670.
- McCain, K. W. (1998). Neural networks research in context: A longitudinal journal co-citation analysis of an emerging interdisciplinary field. *Scientometrics*, 41(3), 389-410.
- Menon, N. M. & Lee, B. (2000). Cost control and production performance enhancement by IT investment and regulation changes: evidence from the healthcare industry. *Decision Support Systems*, 153-169.
- Menon, N. M., Lee, B. & Eldenburg, L. (2000). Productivity of information systems in the healthcare industry. *Information Systems Research*, 83-92.
- Morris, T. A. & McCain, K. W. (1998). The structure of medical informatics journal literature. *Journal of the American Medical Informatics Association*, 5(5), 448-466.
- Murray, E., Lo, B., Pollack, L., Donelan, K., Catania, J., and White, M. (2003). The impact of health information on the internet on the physician-patient relationship. *Archives of Internal Medicine*, 1727-1734.
- Nerur, S. P., Rasheed, A. A. & Natarajan, V. (2008). The intellectual structure of the strategic management field: An author co-citation analysis. *Strategic Management Journal*, 29(3), 319-336.
- Or, C. K. & Karsh, B. T. (2009). A systematic review of patient acceptance of consumer health information technology. *Journal of the American Medical Informatics Association*, 16 (4), 550-560.
- Pilkington, A. & Meredith, J. (2009). The evolution of the intellectual structure of operations management (1980-2006): A citation/co-citation analysis. *Journal of Operations Management*, 27, 185-202.
- Portnoy, D. B., Scott-Sheldon, L. A., Johnson, B. & Carey, M. P. (2008). Computer-delivered interventions for health promotion and behavioral risk reduction: a meta-analysis of 75 randomized controlled trials, 1988-2007. *Preventive Medicine*, 47(1), 3-16.
- Raghupathi, W. & Nerur, S. (2008). Research themes and trends in health information systems. *Methods of Information in Medicine*, 5, 435-442.
- Raghupathi, W. & Nerur, S. (2010). The intellectual structure of health and medical informatics. *International Journal of Healthcare Information Systems and Informatics*, 5(4), 20-34.
- Raghuram, S., Tuertscher, P. & Garud, R. (2010). Mapping the field of virtual work: a co-citation analysis. *Information Systems Research*, 21(4), 983-999.
- Ramanujan, S. & Nerur, S. (2009). An exploratory analysis of the state of software maintenance research: An author co-citation analysis. *Journal of Systems and Information Technology*, 11(2), 117-130.

- Ramos Rodríguez, A. & Ruíz Navarro, J. (2004). Changes in the intellectual structure of strategic management research: A bibliometric study of SMJ. *Strategic Management Journal*, 25(10), 981-1004.
- Ray, G., Muhanna, W. A. & Barney, J. B. (2005). Information technology and the performance of the customer service process: A resource-based analysis. *MIS Quarterly*, 29, 625-652.
- Renaud, A., Walsh, I. & Kalika, M. (2012). An Examination of the Strategic Alignment Literature in IS through Co-Citation Analysis, *Proceedings of Americas Conference on Information Systems*, Seattle.
- Schuemie, M. J., Talmon, J. L., Moorman, P. W. & Kors, J. A. (2009). Mapping the domain of medical informatics. *Methods of Information in Medicine*, 48, 76-95.
- Sircar, S., Nerur, S. P. and Mahapatra, R. (2001). Revolution or evolution? A comparison of object-oriented and structured systems development methods, *MIS Quarterly*, 25, 457-471.
- Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of American Society for Information Science*, 24(4), 265-269.
- Straub D. (2008). Straub, D.W. (2008). Editor's Comments: Thirty Years of Service to the IS Profession: Time for Renewal at MISQ?, *MIS Quarterly*, 32, iii-viii.
- Straub, D. (2006). The value of scientometric studies: An introduction to a debate on IS as a reference discipline. *Journal of the Association for Information Systems*, 7(5), 241-246.
- Tengyue, Z., TianZhi, L., Hongcun, X., Yun, L. & Qing, X. (2011). Profiling frontiers' research published in the Journal of Management Information Systems. *IEEE International Conference on E-Business and E-Government (ICEE)*.
- White, H. (2003). Pathfinder networks and author co-citation analysis: A remapping of paradigmatic information scientists. *Journal of American Society for Information Science & Technology*, 54, 423-434.
- White, H. & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972-1995. *Journal of American Society for Information Science*, 49(4), 327-355.
- Yi, M. Y., Jackson, J. D., Park, J. S. & Probst, J. C. (2006). Understanding IT acceptance by individual professionals: Toward an integrative view. *Information & Management*, 350-363.
- Zhao, D. & Strotmann, A. (2008). Comparing all-author and first-author co-citation analyses of information science. *Journal of Informetrics*, 2(3), 229-239.

Additional Reference for Papers Listed in Tables 1 and 2:

- Amarasingham, R., Plantinga, L., Diener-West, M., Gaskin, D. J. & Powe, N. R. (2009). Clinical information technologies and inpatient outcomes. *Archives of Internal Medicine*, 169(2), 108-114.
- Azad, B. & King, N. (2008). Enacting computer workarounds practices within a medication dispensing system. *European Journal of Information Systems*, 17(3), 264-278.
- Baker, L., Wagner, T. H., Singer, S. & Bundorf, M. K. (2003). Use of the Internet and e-mail for health care information: results from a national survey. *JAMA*, 289(18), 2400-2406.
- Bates, D. W. & Gawande, A. A. (2003). Improving safety with information technology. *New England Journal of Medicine*, 348(25), 2526-2534.
- Berland, G. K., Elliott, M. N., Morales, L. S., Algazy, J. I., Kravitz, R. L., Broder, M. S. & McGlynn, E. A. (2001). Health information on the Internet: accessibility, quality, and readability in English and Spanish. *JAMA*, 285(20), 2612-2621.
- Bhattacharjee, A. & Hikmet, N. (2007). Physicians' resistance toward healthcare information technology: a theoretical model and empirical test. *European Journal of Information Systems*, 16(6), 725-737.
- Bodenheimer, T., Wagner, E. H. & Grumbach, K. (2002). Improving primary care for patients with chronic illness: the chronic care model, Part 2. *JAMA*, 288(15), 1909-1914.
- Braa, J., Hanseth, O., Heywood, A., Mohammed, W. & Shaw, V. (2007). Developing health information systems in developing countries: the flexible standards strategy. *MIS Quarterly*, 381-402.
- Braa, J., Monteiro, E. & Sahay, S. (2004). Networks of action: sustainable health information systems across developing countries. *MIS Quarterly*, 28(3), 337-362.
- Casalino, L., Gillies, R. R., Shortell, S. M., Schmittiel, J. A., Bodenheimer, T., Robinson, J. C. & Wang, M. C. (2003). External incentives, information technology, and organized processes to improve health care quality for patients with chronic diseases. *JAMA*, 289(4), 434-441.
- Chau, P. Y. & Hu, P. J. (2002). Examining a model of information technology acceptance by individual professionals: An exploratory study. *Journal of Management Information Systems*, 18(4), 191-230.

- Chau, P. Y. & Hu, P. J. H. (2002). Investigating healthcare professionals' decisions to accept telemedicine technology: an empirical test of competing theories. *Information & Management*, 39(4), 297-311.
- Cho, S., Mathiassen, L. & Nilsson, A. (2008). Contextual dynamics during health information systems implementation: an event-based actor-network approach. *European Journal of Information Systems*, 17(6), 614-630.
- Davidson, E. J. & Chismar, W. G. (2007). The interaction of institutionally triggered and technology-triggered social structure change: An investigation of computerized physician order entry. *MIS Quarterly*, 739-758.
- Davidson, E. & Chiasson, M. (2005). Contextual influences on technology use mediation: a comparative analysis of electronic medical record systems. *European Journal of Information Systems*, 14(1), 6-18.
- DesRoches, C. M., Campbell, E. G., Rao, S. R., Donelan, K., Ferris, T. G., Jha, A. & Blumenthal, D. (2008). Electronic health records in ambulatory care—a national survey of physicians. *New England Journal of Medicine*, 359(1), 50-60.
- Doolin, B. (2004). Power and resistance in the implementation of a medical management information system. *Information Systems Journal*, 14(4), 343-362.
- Hanseth, O., Jacucci, E., Grisot, M. & Aanestad, M. (2006). Reflexive standardization: Side effects and complexity in standard making. *MIS Quarterly*, 563-581.
- Hesse, B. W., Nelson, D., Kreps, G., Croyle, R. T., Arora, N. K., Rimer, B. K. & Viswanath, K. (2005). Trust and sources of health information: impact of the Internet and its implications for health care providers. *Archives of Internal Medicine*, 165(22), 2618-2624.
- Jensen, T. B. & Aanestad, M. (2007). Hospitality and hostility in hospitals: a case study of an EPR adoption among surgeons. *European Journal of Information Systems*, 16(6), 672-680.
- Jha, A. K., DesRoches, C. M., Campbell, E. G., Donelan, K., Rao, S., Ferris, T. & Blumenthal, D. (2009). Use of electronic health records in US hospitals. *New England Journal of Medicine*, 360(16), 1628-1638.
- Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. & Strom, B. L. (2005). Role of computerized physician order entry systems in facilitating medication errors. *JAMA*, 293, 1197-1203.
- Kuperman, G. J. & Gibson, R. F. (2003). Computer physician order entry: benefits, costs, and issues. *Annals of Internal Medicine*, 139(1), 31-39.
- Lapointe, L. & Rivard, S. (2005). A multilevel model of resistance to information technology implementation. *MIS Quarterly*, 461-491.
- Leimeister, J. M., Ebner, W. & Krcmar, H. (2005). Design, implementation, and evaluation of trust-supporting components in virtual communities for patients. *Journal of Management Information Systems*, 21(4), 101-131.
- Linder, J. A., Ma, J., Bates, D. W., Middleton, B. & Stafford, R. S. (2007). Electronic health record use and the quality of ambulatory care in the U.S. *Archives of Internal Medicine*, 167(13), 1400-1405.
- Liu, L. & Ma, Q. (2005). The impact of service level on the acceptance of application service oriented medical records. *Information & Management*, 42(8), 1121-1135.
- McDonald, C. J. (2006). Computerization can create safety hazards: a bar-coding near miss. *Annals of Internal Medicine*, 144(7), 510-516.
- Menon, N. M., Lee, B. & Eldenburg, L. (2000). Productivity of information systems in the healthcare industry. *Information Systems Research*, 11(1), 83-92.
- Murray, E., Lo, B., Pollack, L., Donelan, K., Catania, J., White, M. & Turner, R. (2003). The impact of health information on the internet on the physician-patient relationship: patient perceptions. *Archives of Internal Medicine*, 163(14), 1727-1734.
- Nebeker, J. R., Hoffman, J. M., Weir, C. R., Bennett, C. L. & Hurdle, J. F. (2005). High rates of adverse drug events in a highly computerized hospital. *Archives of Internal Medicine*, 165(10), 1111-1116.
- Oztekin, A., Pajouh, F. M., Delen, D. & Swim, L. K. (2010). An RFID network design methodology for asset tracking in healthcare. *Decision Support Systems*, 49(1), 100-109.
- Paul, D. L. & McDaniel Jr, R. R. (2004). A field study of the effect of interpersonal trust on virtual collaborative relationship performance. *MIS Quarterly*, 183-227.
- Ray, G., Muhanna, W. A. & Barney, J. B. (2005). Information technology and performance of the customer service process: A resource-based analysis. *MIS Quarterly*, 625-652.
- Simon, S. R., Kaushal, R., Cleary, P. D., Jenter, C. A., Volk, L. A., Orav, E. & Bates, D. W. (2007). Physicians and electronic health records: a statewide survey. *Archives of Internal Medicine*, 167(5), 507-512.

- Tu, Y. J., Zhou, W. & Piramuthu, S. (2009). Identifying RFID-embedded objects in pervasive healthcare applications. *Decision Support Systems*, 46(2), 586-593.
- Weingart, S. N., Toth, M., Sands, D., Aronson, M., Davis, R. & Phillips, R. (2003). Physicians' decisions to override computerized drug alerts in primary care. *Archives of Internal Medicine*, 163(21), 2625-2631.
- Winker, M. A., Flanagan, A., Chi-Lum, B., White, J., Andrews, K., Kennett, R. L. & Musacchio, R. A. (2000). Guidelines for medical and health information sites on the internet. *JAMA*, 283(12), 1600-1606.
- Yi, M. Y., Jackson, J. D., Park, J. S. & Probst, J. C. (2006). Understanding IT acceptance by individual professionals: Toward an integrative view. *Information & Management*, 43(3), 350-363.

Rank	Details of Frequently Co-Cited Paper	Details of Frequently Co-Cited Paper	# Times Co-cited
1	Chau & Hu, 2002, Investigating healthcare professionals' decisions to accept telemedicine technology, I&M	Chau & Hu, 2002, Examining a model of IT acceptance by individual physicians, JMIS	24
2	Chau & Hu, 2002, Investigating healthcare professionals' decisions to accept telemedicine technology, I&M	Yi, Jackson, Park & Probst, 2006, Understanding IT acceptance by individual physicians, I&M	22
3	Yi, Jackson, Park & Probst, 2006, Understanding IT acceptance by individual physicians, I&M	Chau & Hu, 2002, Examining a model of IT acceptance by individual physicians, JMIS	18
4	Bhattacharjee & Hikmet, 2007, Physicians' resistance toward healthcare IT, EJIS	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	15
5T	Davidson & Chismar, 2007, Interaction of institutionally triggered and technology-triggered social structure change, MISQ	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	10
5T	Doolin, 2004, Power and resistance in implementation of a medical management IS, ISJ	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	10
7T	Chau & Hu, 2002, Investigating healthcare professionals' decisions to accept telemedicine technology, I&M	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	8
7T	Paul & McDaniel, 2004, The effect of interpersonal trust on virtual collaborative relationship performance, MISQ	Leimeister et al, 2005, Trust-supporting components in virtual communities for patients, JMIS	8
9T	Chau & Hu, 2002, Examining a model of IT acceptance by individual physicians, JMIS	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	7
9T	Chau & Hu, 2002, Investigating healthcare professionals' decisions to accept telemedicine technology, I&M	Liu & Ma, 2005, The impact of service level on the acceptance of application service oriented medical records, I&M	7
9T	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	Hanseth et al, 2006, Reflexive standardization: Side effects and complexity in standard making, MISQ	7
9T	Menon, Lee & Eldenburg, 2000, Productivity of IS in the healthcare industry, ISR	Ray, Muhanna & Barney, 2005, IT and the performance of the customer service process, MISQ	7
13T	Azad & King, 2008, Enacting computer workaround practices within a medication dispensing system, EJIS	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	6
13T	Braa, Monteiro & Sahay, 2004, Networks of action: Sustainable HIS across developing countries, MISQ	Braa, Hanseth, et al, 2007, Developing health IS in developing countries, MISQ	6
13T	Chau & Hu, 2002, Examining a model of IT acceptance by individual physicians, JMIS	Bhattacharjee & Hikmet, 2007, Physicians' resistance toward healthcare IT, EJIS	6
13T	Chau & Hu, 2002, Investigating healthcare professionals' decisions to accept telemedicine technology, I&M	Bhattacharjee & Hikmet, 2007, Physicians' resistance toward healthcare IT, EJIS	6
13T	Davidson & Chiasson, 2005, Contextual influences on technology use mediation, EJIS	Cho, Mathiassen et al., 2008, Contextual dynamics during health IS implementation, EJIS	6
13T	Davidson & Chiasson, 2005, Contextual influences on technology use mediation, EJIS	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	6
13T	Jensen & Aanestad, 2007, Hospitality and hostility in hospitals, EJIS	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	6
13T	Tu et al, 2009, Identifying RFID-embedded objects in pervasive healthcare applications, DSS	Oztekun et al, 2010, An RFID network design methodology for asset tracking in healthcare, DSS	6
13T	Yi, Jackson, Park & Probst, 2006, Understanding IT acceptance by individual physicians, I&M	Liu & Ma, 2005, The impact of service level on the acceptance of application service oriented medical records, I&M	6
13T	Yi, Jackson, Park & Probst, 2006, Understanding IT acceptance by individual physicians, I&M	Lapointe & Rivard, 2005, A multilevel model of resistance to IT implementation, MISQ	6

Table 1. Most Frequently Co-cited Papers in IS Journals

Rank #	Details of Frequently Co-cited Paper	Details of Frequently Co-cited Paper	# Times Co-cited
1	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Nebeker et al, 2005, High rates of adverse drug events in a highly computerized hospital, Archives of Internal Medicine	95
2	DesRoches et al, 2008, Electronic health records in ambulatory care, NEJM	Jha et al, 2009, Use of electronic health records in US hospitals, NEJM	89
3	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Bates & Gawande, 2003, Improving safety with IT, NEJM	71
5	Baker, 2003, Use of the Internet and e-mail for health care information, JAMA	Hesse et al, 2005, Trust and sources of health information, Archives of Internal Medicine	48
6	Bodenheimer et al, 2002, Improving primary care for patients with chronic illness, JAMA	Casalino et al, 2003, improve health care quality for patients with chronic diseases, JAMA	47
7	Berland et al, 2001, Health information on the Internet, JAMA	Winker et al, 2000, Guidelines for medical and health information sites on the Internet, JAMA	43
8	DesRoches et al, 2008, Electronic health records in ambulatory care, NEJM	Linder et al, 2007, Electronic health record use and quality of ambulatory care in the U.S., Archives of Internal Medicine	41
9	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Weingart et al, 2003, Physicians' decisions to override computerized drug alerts in primary care, Archives of Internal Medicine	36
10T	Baker, 2003, Use of the Internet and e-mail for health care information, JAMA	Berland et al, 2001, Health information on the Internet, JAMA	35
10T	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Jha et al, 2009, Use of electronic health records in U.S. hospitals, NEJM	35
12T	Baker, 2003, Use of the Internet and e-mail for health care information, JAMA	Murray et al, 2003, The impact of health information on the Internet on physician-patient relationship, Archives of Internal Medicine	32
12T	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	McDonald, C. J. 2006). Computerization can create safety hazards, Annals of Internal Medicine	32
14	DesRoches et al, 2008, Electronic health records in ambulatory care, NEJM	Simon et al, 2007, Physicians and electronic health records, Archives of Internal Medicine	30
15T	Berland et al, 2001, Health information on the Internet, JAMA	Hesse et al, 2005, Trust and sources of health information, Archives of Internal Medicine	29
15T	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Linder et al, 2007, Electronic health record use and quality of ambulatory care in the U.S., Archives of Internal Medicine	29
17	Jha et al, 2009, Use of electronic health records in US hospitals, NEJM	Amarasingham et al, 2009, Clinical IT and inpatient outcomes, Archives of Internal Medicine	27
18	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	DesRoches et al, 2008, Electronic health records in ambulatory care, NEJM	25
19T	Bates & Gawande, 2003, Improving safety with information technology, NEJM	Kuperman & Gibson, 2003, Computer physician order entry, Annals of Internal Medicine	24
19T	Koppel et al, 2005, Role of computerized physician order entry systems in facilitating medication errors, JAMA	Amarasingham et al, 2009, Clinical IT and inpatient outcomes, Archives of Internal Medicine	24

Table 2. Most Frequently Co-cited Papers in Medical Journals

Article Title	F1 – HIT in Organization Settings	F2 – IT Adoption & Acceptance	F3 – IT Investment & Pay-off	F4 – Data & Info Integration	F5 – Telehealth	F6 – RFID Technology & Mobile Technology	F7 – Online Communities	F8 – Health in Developing Countries	F9 – Telehealth	F10 – Electronic Patient Records Security & Privacy
Power and resistance in the implementation of a medical management information system	.949									
Enacting computer workaround practices within a medication dispensing system	.937									
Hospitality and hostility in hospitals: a case study of an EPR adoption among surgeons	.901									
Multiple Group Coordination in Complex and Dynamic Task Environments: Interruptions, Coping Mechanisms, and Technology Recommendations	.898									
Contextual influences on technology use mediation: a comparative analysis of electronic medical record systems	.895									
Reflexive standardization: Side effects and complexity in standard making	.889									
THE INTERACTION OF INSTITUTIONALLY TRIGGERED AND TECHNOLOGY-TRIGGERED SOCIAL STRUCTURE CHANGE: AN INVESTIGATION OF COMPUTERIZED PHYSICIAN ORDER ENTRY	.794		.469							
Explaining changes in learning and work practice following the adoption of online learning: a human agency perspective	.793									
Time to rethink health care and ICT?	.753									
A critical approach to evaluation	.748									
The biggest computer programme in the world ever! How's it going?	.744									
The "Soft" Information Systems and Technologies Methodology" (SISTeM): an actor network contingency approach to integrated development	.736									
The role of industry infrastructure in telehealth innovations: a multi-level analysis of a telestroke program	.733				.575					
Conflicting institutional logics: a national programme for IT in the organisational field of healthcare	.724									
Evaluating healthcare information systems through an "enterprise" perspective	.673	.487								
NETWORKS OF ACTION: SUSTAINABLE HEALTH INFORMATION SYSTEMS ACROSS DEVELOPING COUNTRIES	.669									
Contextual dynamics during health information systems implementation: an event-based actor-network approach	.637									
The adoption and use of GSS in project teams: Toward more participative processes and outcomes	.635				.615					
Local sociotechnical system development in the NHS National Programme for Information Technology	.632									
The biggest computer programme in the world...ever!": time for a change in mind?	.605									
Lessons learned from three interorganizational health care information systems	.966									
The impact of service level on the acceptance of application service oriented medical records	.949									
Investigating healthcare professionals' decisions to accept telemedicine technology: an empirical test of competing theories	.945									
Adoption of Telemedicine Technology by Health Care Organizations: An Exploratory Study	.900									
Understanding information technology acceptance by individual professionals: Toward an integrative view	.896									
Examining a Model of Information Technology Acceptance by Individual Professionals: An Exploratory Study	.877									
Time-Critical Information Services	.872									
An empirical examination of patient-physician portal acceptance	.850									
Physicians' resistance toward healthcare information technology: a theoretical model and empirical test	.616	.713								
A multilevel model of resistance to information technology implementation	.661									
An exploratory study of radio frequency identification (RFID) adoption in the healthcare industry	.632					.587				
Cost control and production performance enhancement by IT investment and regulation changes: evidence from the healthcare industry	.965		.965							
The Digital Transformation of Healthcare: Current Status and the Road Ahead	.945		.945							
An Empirical Investigation of the Value of Integrating Enterprise Information Systems: The Case of Medical Imaging Informatics	.883		.883							
Using regression splines to assess the impact of information technology investments on productivity in the health care industry	.881		.881							
Information technology and the performance of the customer service process: A resource-based analysis	.844		.844							
Differential Effects of the Two Types of Information Systems: A Hospital-Based Study	.823		.823	.504						
An organizational learning perspective on the assimilation of electronic medical records among small physician practices	.757		.757							
Casting the Net: A Multimodal Network Perspective on User-System Interaction	.505	.719	.719							
The antecedents of CIO role effectiveness in Organizations: An empirical study in the healthcare sector	.670	.476	.476							
HIT and MIS: Implications of health information technology and medical information systems	.426	.453	.453							
Knowledge integration and information technology project performance	.888		.888							
Understanding the influence of information systems competencies on process innovation: A resource-based view	.877		.877							
Integration in electronic exchange environments	.852		.852							
An exploratory model of knowledge flow barriers within healthcare organizations	.760		.760							
Fighting against windmills: Strategic information systems and organizational deep structures	.557		.681							
Information processing design choices, strategy, and risk management performance	.501		.644							
Productivity of Information Systems in the Healthcare Industry	.424	.466	.634							
Collaborative activities in virtual settings: A knowledge management perspective of telemedicine	.902		.902							
Is Telemedicine the Panacea for Sub-Saharan Africa's Medical Nightmare?	.884		.884							
Dialectics of resilience: a multi-level analysis of a telehealth innovation	.507	.768	.768							
Design, implementation, and evaluation of trust-supporting components in virtual communities for patients	.746		.746							
SECURITY ISSUES FOR IMPLEMENTATION OF E-MEDICAL RECORDS	.616		.616							.409
Examining the success factors for mobile work in healthcare: A deductive study	.524		.524			.675				
Factors affecting the adoption of electronic signature: Executives' perspective of hospital information department	.585	.658	.658			.658				
Identifying RFID-embedded objects in pervasive healthcare applications	.627		.627			.627				
An RFID network design methodology for asset tracking in healthcare	.585		.585			.585				
Evaluating the adoption of enterprise application integration in healthcare organizations	.457		.457			.532				
Neo-tribes: the power and potential of online communities in health care	.950		.950							
Dynamics of trust revision: Using health infomediaries	.834		.834							
Trust-building Measures: A Review of Consumer HEALTH PORTALS	.703		.703							
A field study of the effect of interpersonal trust on virtual collaborative relationship performance	.692		.692							
Personal Health Information Management	.546		.546							
TELEMEDICINE IN THE UPPER AMAZON: INTERPLAY WITH LOCAL HEALTH CARE PRACTICES	.876		.876							
DEVELOPING HEALTH INFORMATION SYSTEMS IN DEVELOPING COUNTRIES: THE FLEXIBLE STANDARDS STRATEGY	.861		.861							
Configurable Politics and Asymmetric Integration: Health e-Infrastructures in India	.482	.685	.685							
A design science research methodology for Information Systems Research	.950		.950							
Telehealth acquires meanings: information and communication technologies within health policy	.790		.790							
Asynchronous health care communication	.754		.754							
Is telemedicine a practical reality?	.400	.448	.448							
The SI challenge in health care	.553		.553							
Identifying healthcare actors involved in the adoption of information systems	.433		.433							
A Survey and Analysis of Electronic Healthcare Record Standards	.737		.737							
The HIPAA-potamus in Health Care Data Security	.648		.648							
ADOPTION OF ELECTRONIC HEALTH RECORDS IN THE PRESENCE OF PRIVACY CONCERNS: THE ELABORATION LIKELIHOOD MODEL AND INDIVIDUAL PERSUASION	.529		.529							
Antecedents and Dimensions of Online Service Expectations										

Figure 1. Factor Analysis Result for HIT Articles in IS Journals

Article Title	F1-General IT in Healthcare	F2-Healthcare Quality Issues	F3-Availability of Internet on Patients	F4-Doctor-Patient Communication	F5-IT in minimize diagnostic errors	F6-Effect of health IT on patient outcomes	F7-IT-based DSS	F8-IT for Safety Alerts	F9-Quality Measures
Computerization can create safety hazards: A bar-coding near miss	.962								
High rates of adverse drug events in a highly computerized hospital	.956								
Computer physician order entry: Benefits, costs, and issues	.946								
Physicians' decisions to override computerized drug alerts in primary care	.941								
Effect of an Electronic Medication Reconciliation Application and Process Redesign on Potential Adverse Drug Events A Cluster-Randomized Trial	.930								
Patient safety: Improving safety with information technology	.912								
Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates - a randomized trial	.910								
Using information technology to improve the health care of older adults	.909								
The long road to patient safety - A status report on patient safety systems	.903								
The patient-owned, population-based electronic medical record: A revolutionary resource for clinical medicine	.824								
Getting physicians to accept new information technology: Insights from case studies	.823	.466							
Electronic Health Records and Malpractice Claims in Office Practice	.751	.443							
Responding to the rofecoxib withdrawal crisis: A new model for notifying patients at risk and their health care providers	.715	.404		.507					
A randomized outpatient trial of a decision-support information technology tool	.709						.459		
Clinical Information Technologies and Inpatient Outcomes	.696	.465				.469			
The costs of a national health information network	.680	.614							
The effect of automated alerts on provider ordering behavior in an outpatient setting	.662							.408	
Fall Prevention in Acute Care Hospitals A Randomized Trial	.603						.565		
Role of computerized physician order entry systems in facilitating medication errors	.602								
Improving imperfect data from health management information systems in Africa using space-time geostatistics									
The Regional Extension Center Program: Helping Physicians Meaningfully Use Health Information Technology		.957							
An Electronic Practice-Based Network for Observational Comparative Effectiveness Research		.910							
Health Information Exchange Participation by Minnesota Primary Care Practices		.887							
Physicians and electronic health records - A statewide survey		.887							
Quality improvement with an electronic health record: Achievable, but not automatic		.880							
Use of Electronic Health Records in U. S. Hospitals	.441	.857							
Associations Between Structural Capabilities of Primary Care Practices and Performance on Selected Quality Measures		.834		.426					
Electronic health records: Just around the corner? Or over the cliff?	.420	.809							
Effect of Electronic Prescribing With Formulary Decision Support on Medication Use and Cost		.792							
Electronic health record use and the quality of ambulatory care in the United States	.555	.754							
Information technology comes to medicine	.439	.714				.451			
Comparison of quality of care for patients in the Veterans Health Administration and patients in a national sample	.438	.654		.427					
Practice-linked online personal health records for type 2 diabetes mellitus - A randomized controlled trial	.457	.639							
HEALTH CARE REFORM Patients Treated at Multiple Acute Health Care Facilities Quantifying Information Fragmentation		.616							
The impact of health information on the Internet on the physician-patient relationship - Patient perceptions			.918						
Trust and sources of health information - The impact of the Internet and its implications for health care providers: Findings from the first Health Information National Trends Survey			.906						
Analysis of cases of harm associated with use of health information on the Internet			.905						
Awareness of sources of peer-reviewed research evidence on the Internet			.898						
Does pornography-blocking software block access to health information on the Internet?			.895						
Users' guides to the medical literature - XXI. Using electronic health information resources in evidence-based practice			.891						
Guidelines for medical and health information sites on the Internet - Principles governing AMA Web sites			.868						
Health information on the Internet - Accessibility, quality, and readability in English and Spanish			.864						
Use of the Internet and e-mail for health care information - Results from a national survey			.845						
Adverse events associated with dietary supplements: an observational study			.824						
Internet use among Ugandan adolescents: Implications for HIV intervention			.824						
Promoting informed choice: Transforming health care to dispense knowledge for decision making			.960						
External incentives, information technology, and organized processes to improve health care quality for patients with chronic diseases			.936						
National health information privacy - Regulations under the Health Insurance Portability and Accountability Act			.925						
Coordinating care across diseases, settings, and clinicians: A key role for the generalist in practice		.473	.833						
Chronic Diseases: Chronic Diseases and Development 4 Prevention and management of chronic disease: a litmus test for health-systems strengthening in low-income and middle-income countries			.812						
Electronic technology - A spark to revitalize primary care?		.456	.678						
Patients' interest in reading their medical record - Relation with clinical and sociodemographic characteristics and patients' approach to health care	.467		.471						
Identifying diagnostic errors in primary care using an electronic screening algorithm					.929				
Missed hypothyroidism diagnosis uncovered by linking laboratory and pharmacy data					.916				
Frequency of Failure to Inform Patients of Clinically Significant Outpatient Test Results					.901				
Failure to Recognize Newly Identified Aortic Dilations in a Health Care System With an Advanced Electronic Medical Record					.900				
Timely Follow-up of Abnormal Diagnostic Imaging Test Results in an Outpatient Setting Are Electronic Medical Records Achieving Their Potential?	.432				.709				
Impact of an automated test results management system on patients' satisfaction about test result communication	.485				.605				
Communication and information technology in medical education					.481				
Association of Health Information Technology and Teleintensivist Coverage With Decreased Mortality and Ventilator Use in Critically Ill Patients						.947			
National Quality Forum Performance Measures for HIV/AIDS Care The Department of Veterans Affairs' Experience						.947			
The Affordable Care Act and the Future of Clinical Medicine: The Opportunities and Challenges						.930			
Electronic health records in ambulatory care - A national survey of physicians						.772			
The electronic medical record							.889		
An Electronic Health Record-Based Intervention to Improve Tobacco Treatment in Primary Care A Cluster-Randomized Controlled Trial							.713		
Improving primary care for patients with chronic illness							.552		
Can we achieve health information for all by 2015?									
Effect of Bar-Code Technology on the Safety of Medication Administration.								.676	
Tuberculosis 7 Health-system strengthening and tuberculosis control								.676	
Clinicians' Assessments of Electronic Medication Safety Alerts in Ambulatory Care	.502		.431					.549	
The impact of prescribing safety alerts for elderly persons in an electronic medical record - An interrupted time series evaluation	.478		.405					.537	
Reducing warfarin medication interactions - An interrupted time series evaluation	.475		.417					.510	
Can This Patient Read and Understand Written Health Information?									
Frequency of Inappropriate Medical Exceptions to Quality Measures									.796
Automated review of electronic health records to assess quality of care for outpatients with heart failure									.734
Assessing the validity of national quality measures for coronary artery disease using an electronic health record									.724

Figure 2. Factor Analysis Result for HIT Articles in Medical Journals

IS Journals		Medicine Journals	
Factor Title	% of Variance	Factor Title	% of Variance
HIT in organizational settings	23.3	General IT in Healthcare	38.9
IT adoption and acceptance	16.9	Healthcare quality issues	14.1
Business value of IT	15.6	Availability of Internet resources on patients	8.7
Data integration	9.1	Doctor-patient communication (e.g., portals)	7.2
Telehealth	6.8	IT to minimize diagnostic errors	5.9
RFID & Mobile Technology	4.0	Effect of health IT on patient outcomes	4.3
Online communities	3.3	Decision support systems (DSS)	3.3
Healthcare in developing countries	2.6	IT for safety alerts	2.8
Security and privacy issues for electronic patient records	1.8		

Table 3. Factor Analysis Result in Information Systems and Medicine