Journal of the Association for Information Systems (2019) **20**(8), 1023-1074
doi: 10.17705/1jais.00561

RESEARCH PAPER

ISSN 1536-9323

An Analysis of the Evolving Intellectual Structure of Health Information Systems Research in the Information Systems Discipline

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Abstract

The rapid evolution of health information systems (Health IS) research has led to many significant contributions. However, while the Health IS subset of information systems (IS) scholarship has considerably grown over the past two decades, this growth has led to questions regarding the current intellectual structure of this area of inquiry. In an effort to more fully understand how Health IS research has contributed to the IS discipline, and what this may mean for future Health IS research in the IS domain, we conduct an in-depth evaluation of Health IS research published in mainstream IS journals. We apply citation analysis, latent semantic analysis (LSA), and social network analysis (SNA) to our data set of Health IS articles in order to: (1) identify Health IS research themes and thematic shifts, (2) determine which Health IS research themes are cohesive (versus disparate), (3) identify which Health IS research themes are central (versus peripheral), (4) clarify networks of researchers (i.e., thought leaders) contributing to these research themes, and (5) provide insights into the connection of Health IS research to its reference disciplines. Overall, we contribute a systematic description and explanation of the intellectual structure of Health IS research and highlight how the existing intellectual structure of Health IS research provides opportunities for future research.

Keywords: Health Information Systems (Health IS), Intellectual Structure, Scientometrics, Citation Analysis, Latent Semantic Analysis (LSA), Social Network Analysis (SNA), Thought Leadership.

Paul Benjamin Lowry was the accepting senior editor. This research article was submitted on May 14, 2017 and underwent three revisions.

1 Introduction

Health information systems (Health IS, or HIS) research has become a subdiscipline of significant interest to information systems (IS) scholars (Agarwal, Gao, DesRoches, & Jha, 2010; Fichman, Kohli, & Krishnan, 2011; Kohli & Tan, 2016). While our knowledge is rapidly growing in this area (Agarwal, 2016; Agarwal et al., 2010; Chiasson & Davidson, 2004; Gallivan & Tao, 2014; Morris & McCain, 1998; Raghupathi & Nerur, 2008; Raghupathi & Nerur, 2010; Romanow, Sunyoung, & Straub, 2012), comprehensive evaluation of thematic and authorial structures has not been fully addressed, particularly more recently, leaving a research gap for fully investigating the intellectual structure of Health IS research. We suggest that a comprehensive analysis of the intellectual structure of Health IS research IS presents a unique opportunity to formalize our existing thinking in this important area of research and provide a systematic foundation on which to build future Health IS research.

This is a particularly important investigation, as gaining deep insights into the intellectual structure of a discipline can lead to defining moments for a community of scholars (Kuhn, 1962). At these

defining moments, the intellectual structure either reifies what is already known in the knowledge base or else increments it (Kuhn, 1962). Consideration of such structures can shape the epistemologies that frame knowledge development work and alter the philosophical basis of these efforts (Crane, 1972). Structural knowledge can help scholars set their future research directions by seeing patterns of work that have existed in the past and paying attention to trend lines into the future (Platt, 1964). Many authors see intellectual structures as a critical aspect of the history of a field (Abbott, 1999; Grafton, 2006). In particular, an intellectual structure underlying a discipline develops over time as research themes and thought leaders emerge and mature. However, identifying such themes and thought leaders and the underlying structure between these elements is often difficult without comprehensive data analysis.

Therefore, we seek to create a comprehensive understanding of the intellectual structure of Health IS research its connection to its reference disciplines. We contend that future contributions will be further enhanced if they draw from a comprehensive understanding of the relationships between structural elements within Health IS research to date, thereby generating comprehensive, grounded, and well-informed contributions that help to move the domain of IS forward. We specifically propose that future progress is dependent on: (1) a more recent and complete understanding of how the Health IS research subdiscipline has grown and evolved thematically over the past 28 years (our Health IS data span the period from 1990 to 2017), (2) more in-depth explanation of the structural relationships within and between research themes, (3) identification of thought leaders contributing to these research themes (following scientometric and information science research that often focuses on authorial structures within scientific disciplines—e.g., Leydesdorff, 2005; White & Griffith, 1981), (4) identification of how Health IS research and its reference fields are related, and (5) leveraging these intellectual structure analyses to guide future research. Given the importance of this profession and discipline, and the need for a better understanding of the intellectual structure of Health IS research, our research questions are:

RQ: What is the intellectual structure of Health IS research? Related questions include:

1. What are the research themes that represent the Health IS research subdiscipline to date?
2. What thematic shifts have occurred over time?
3. Which research themes are the most cohesive (versus disparate)?
4. Which research themes are the most central (versus peripheral)?
5. Who are the intellectual leaders contributing to Health IS?
6. How does Health IS research connect to its reference fields?

The organization of this paper is as follows. First, we cover the relevant research and literature. Then, we discuss our sampling strategy and scientometrically based multimethodological analysis techniques, including citation analysis, latent semantic analysis (LSA), and social network analysis (SNA). We then analyze a data set of 571 Health IS articles from 1990 to 2017 drawn from mainstream IS journals and provide detailed results. We discuss contributions and implications of these analyses and results. Finally, we conclude with observations about the state of the intellectual structure of Health IS research, areas that appear to be most fruitful for future work, and thoughts on how Health IS research may help move the IS research domain forward.

2 Background and Literature Review

2.1 Intellectual Structures of Scientific Disciplines

A *discipline* or field of study is a community of scholars and teachers who develop expertise in a self-defined domain of knowledge (Abbott, 1988). A discipline is distinguished, in part, by the power this group exercises over expert matter, the more abstract term for such a community being the term "profession" (Abbott, 1988). Combining these terms leads us to the concept of an academic professional discipline, which contributes to knowledge in very specific intellectual domains. Intellectual knowledge creation within such domains grows and evolves over time as scholars conduct geographically and temporally dispersed research.

The term *intellectual structure* fundamentally has to do with the ideas and relationships between ideas that form the basis for impactful research. In this sense, an intellectual structure is a historical approach to knowledge creation and advancement in the sense that historians speak and write about the intellectual history of an era or a people. More specifically, while the term "intellectual" refers to ideas, "structure" refers to the organization of the ideas themselves and to relationships and distinctions between ideas and among themes and contributors. Additionally, the structure of a field depends not only on the ideas and knowledge being generated, but also on how such ideas and knowledge are thematically similar or

dissimilar, as well as on the thought leaders[1] who contribute to a discipline's knowledge base. As these patterns develop, cohere (or fragment), and become more central (or peripheral) over time, knowledge builds and paradigms compete until the community senses the need for a change and the paradigm shifts (Culnan, 1987; Kuhn, 1962).

A complete understanding of the intellectual structure of a discipline requires more than simply knowing that research has been conducted in an area or that particular articles have been especially influential. Rather, it requires that we understand the structure of the knowledge in the form of networks of studies that have been conducted and then, over time, how thematic consolidation (or fragmentation) has become more (or less) central and associated with more (or less) density within a network of scientific knowledge (Hou, Kretschmer, & Liu, 2007). Developing such structural knowledge of the intellectual contributions of a research domain requires in-depth analysis of how publications are related to each other, through methods such as generic citation analysis, social network analysis of citations and author networks (Hou et al., 2007; Otte & Rousseau, 2002), as well as content analysis methods such as latent semantic analysis that allow researchers to develop more in-depth knowledge of thematic foci and relationships (Magerman, Van Looy, & Song, 2010; Tonta & Darvish, 2010). In fact, the importance of understanding and explaining relationships associated with scientific studies, themes that emerge within knowledge areas, and focal authors has been consistently demonstrated in scientometric studies conducted in business-related disciplines, such as strategy (Ramos-Rodríguez & Ruíz-Navarro, 2004), operations (Pilkington & Meredith, 2009), and communication (Lowry, Humpherys, Malwitz, & Nix, 2007), as well as in the IS domain via intellectual structure studies conducted on core concepts and themes within the IS discipline as a whole (Culnan, 1986, 1987; Lowry et al., 2013; Lowry, Romans, & Curtis, 2004; Sidorova, Evangelopoulos, Valacich, & Ramakrishnan, 2008), human-computer interaction (Li & Zhang, 2005; Zhang, Li, Scialdone, & Carey, 2009), crowdsourcing within the IS domain (Zhao & Zhu, 2014), IS strategy (Merali, Papadopoulos, & Nadkarni, 2012), and even for specific IS journals (e.g., *Information Systems Research*, Agarwal, 2016).

2.2 The Intellectual Structure of Health IS

Given that Health IS research is a multidisciplinary field that holds significant potential to contribute to the IS discipline and other coordinate disciplines, we might wish to conceptualize Health IS research as a well-defined, bounded body of knowledge, distinct from other disciplines. Reality is, of course, much more complex. Abbott used a fractal distinctions model of disciplinary development to show that the boundaries between academic disciplines are amorphous and ephemeral; this notwithstanding, many disciplines have an "axis of cohesion" (Abbott, 2001, p. 144). Abbott argues that when fields attempt to shift and up-scope their domain of interest, they inevitably move beyond their traditional boundaries and seek out interdisciplinary intellectual spaces. Rather than clarifying themselves through refinements, disciplines are continually fragmenting and cohering along varying and shifting themes across thought and method. Additionally, scientific disciplines are self-defined and self-evolving to a large extent, making full understanding of intra- and interdisciplinary relationships a challenge. Therefore, there is a need to more fully understand the underlying dynamics of their intellectual structures.

This raises the question: How has Health IS research been previously analyzed and why does the existing work need to be augmented with additional efforts? Literature reviews, systematic reviews (a term widely used by the medical community to indicate a rigorous literature search and review of a specific topic), and commentaries have been published (e.g., Agarwal et al., 2010; Andrews, 2003; Baird, Angst, & Oborn, 2018; Chiasson et al., 2004; Davidson, Baird, & Prince, 2018; Davidson & Chiasson, 2005; Eggers et al., 2005; Morris et al., 1998; Raghupathi et al., 2008; Raghupathi et al., 2010; Romanow et al., 2012; Schuemie, Talmon, Moorman, & Kors, 2009; Vishwanatham, 1998), but analyses of the deeper level of the intellectual structures of Health IS research are needed, especially from the IS scholar's perspective. Up to this point, systematic analyses of Health IS research have focused primarily on: (1) how the health care context contributes to IS theory building and validation (e.g., Chiasson et al., 2004; Davidson et al., 2018); (2) reviews of research trends in the Health IS literature (e.g., Baird et al., 2018; Romanow et al., 2012); and (3) informed opinions regarding where the Health IS discipline may be headed (e.g., Agarwal et al., 2010). Focusing on one aspect of this, the substantial quantity of empirical research work carried out on the impact of Health IS on performance outcomes (such as cost, quality, and efficiency) has been systematically reviewed numerous times, typically drawing from the literature of many disciplines that coordinate with Health IS, including health management and health services research (e.g., Buntin, Burke, Hoaglin, & Blumenthal, 2011; Jamal, McKenzie, & Clark, 2009; Lau, Kuziemsky, Price, & Gardner, 2010; Poissant, Pereira, Tamblyn, & Kawasumi, 2005; Wu et al., 2006). Findings related to

[1] In the diffusion of innovation literature (Rogers, 1996), thought leaders are referred to as "opinion leaders" and they are deemed to be instrumental in the dissemination of new ideas.

the use of Health IS (and "meaningful use" incentives in the US—see Blumenthal & Tavenner, 2010) have also been systematically reviewed. Such reviews typically synthesize the relevant literature from coordinate disciplines such as health policy (e.g., Jones, Rudin, Perry, & Shekelle, 2014).

What is glaringly missing from this useful and informative work, unfortunately, is an analysis of the recent intellectual structure of the Health IS literature, especially as Health IS implementations have evolved significantly in recent years within the IS discipline. Further, an objective analysis of themes, network, thought leadership, and the connection between Health IS research and its reference disciplines is needed, via a rigorous application of scientometric methods, to better understand how this domain has developed. Thus, a comprehensive and recent analysis of the intellectual structure of Health IS research is needed for IS scholars to better understand how the subdiscipline has evolved and how we as IS scholars could conceivably help to forward our own domain when conducting Health IS research.

3 Methods

Our intellectual structural analysis was guided by and contributes to the relevant and rigorous domain of scientometrics, which includes bibliometrics and informetrics (Hood & Wilson, 2001). All three of these areas are closely related: scientometrics focuses on quantitative analysis of scientific knowledge development, bibliometrics primarily focuses on citations and relationships between citing articles and sources, and informetrics focuses on the social creation and evolution of information (Hood et al., 2001). We refer to these fields generally by the widely used term "scientometrics."

In particular, this research employs as its major scientometric methods: (1) citation analysis, (2) latent semantic analysis (LSA), and (3) social network analysis (SNA). These techniques form the foundation of our multimethod scientometric approach which, overall, includes: (1) data collection and sampling, (2) extraction of research themes via LSA, (3) construction of citation relationships, (4) analyzing interthematic level citation relationship, and (5) conducting SNA for the purposes of understanding intrathematic impact and thought leaders. Figure 1 shows the sampling frame employed for the Health IS article data set collection and the subsequent data analysis procedures.

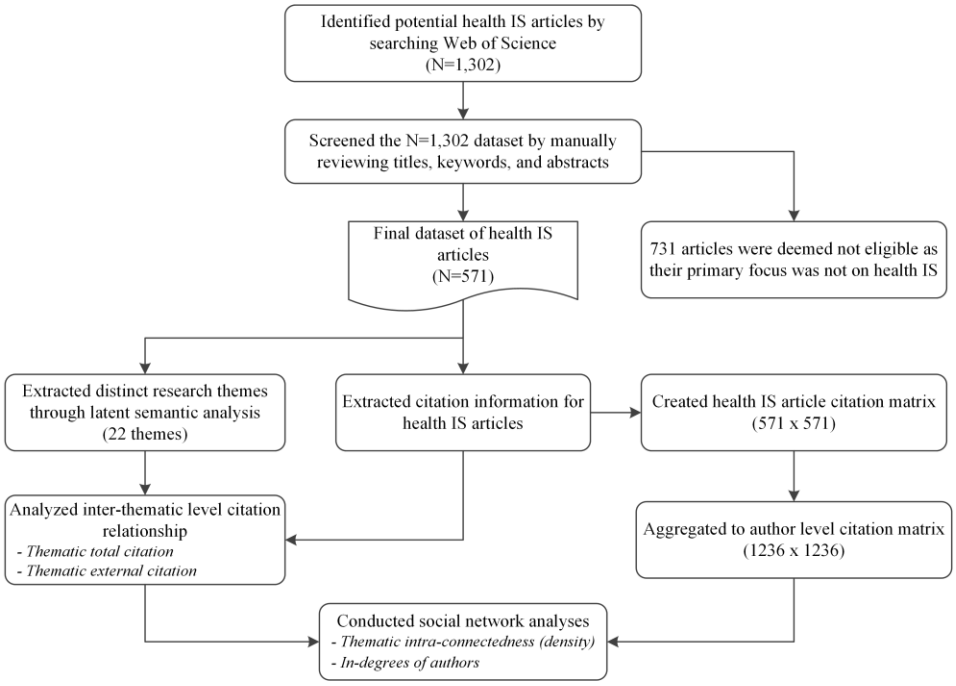


Figure 1. Sampling Frame and Data Analysis Procedures

3.1 Data Collection and Sampling Procedure

Article information was retrieved from Web of Science (formerly Institute for Scientific Information, or ISI), which contains source article information and a comprehensive reference/citation list (Bernroider, Pilkington, & Córdoba, 2013). The selection criteria for the Health IS research field were largely determined by which journals had published at least

three articles on Health IS and thus were empirically driven rather than imposed a priori by the authors of this study. This criterion assured that the journals had a track record in Health IS research and that publication of such articles was not an anomaly. The journals also had to be indexed by Web of Science. Both of these criteria were thus driven by the empirical needs of the project; these criteria made the project tractable. Null sets are just not relevant when examining relationships between themes and between authors.

An additional criterion gave reasonable assurance that the final data set of articles was, to a large extent, representative of the entire IS field. According to Lowry et al. (2013), the top tier journals in IS are *MIS Quarterly*, *Information Systems Research*, and *Journal of Management Information Systems*. A second tier contains the other members of the AIS Senior Scholars' "Basket of Eight,"[2] including the *Journal of the AIS*, *European Journal of Information Systems*, *Information Systems Journal*, *Journal of Information Technology*, and *Journal of Strategic Information Systems*. Since all of these tiers were included, as well as additional journals via our sampling strategy, we thus oversampled from the highest quality journals. This bias was purposeful in that we wanted to be sure that the best journals in the field played a sizable role in our findings regarding key themes and key leaders.

Our sampling frame included a group of randomly selected journals from other tiers of IS journals (and journals that publish IS articles) that had published Health IS articles. These well-regarded journals include *Decision Support Systems*, *Communications of the AIS*, *Information & Management*, *Information Systems Frontiers*, *International Journal of Information Management*, *Information Systems Management*, *Information Technology & People*, *Journal of Computer Information Systems*, *Information Society*, *Information and Organization*, *Management Science*, *Human Relations*, *Organization Studies*, and *Organization Science*.[3]

In brief, the selection criteria for the study has characteristics of both representativeness and high quality. It is not a random sample of all journals, nor is it, strictly speaking, a "convenience" sample. Rather, it is a "purposive" sample, consistent with Trochim et al.'s definition (2016) and with the research goals of this study.

Data collection relied on terms used in previous systematic reviews (Higgins & Green, 2008). Multiple healthcare-related keywords (including "healthcare," "health care," "health-care," "health," "medical," "medicine," "clinical," "hospital," "physician," "doctor," "patient," and "nurse") were combined with the 22 selected journals to retrieve articles potentially focused on Health IS.[4] We limited our search to academic articles in the English language and in the Web of Science core collection of databases. As a result, 1,302 articles formed the initial data set spanning the 28-year period from 1990 to 2017.[5] To refine the data set, we examined the title, keywords, and abstract of each paper in order to exclude articles that were included in the search result, but not actually related to Health IS. For instance, the word "health" appeared in many articles that were not actually focused on Health IS, but rather used the term to refer to the "health of information systems" or in similar, but not relevant, ways. Further, a number of articles used the health context to analyze phenomena not related to Health IS and thus were excluded if they did not contribute to the Health IS literature through analysis of a Health IS artifact. This filtering process resulted in a final data set of 571 Health IS articles, which is consistent with other reviews of Health IS literature when considering that additional articles have been published since such reviews were conducted (e.g., Romanow et al., 2012). Summaries of Health IS publications from this data set appear in Appendix A.

[2] These eight journals are further described at http://aisnet.org/general/custom.asp?page=SeniorScholarBasket

[3] We note that some issues of some journals were excluded. This was due to either their lack of indexing by Web of Science (as is the case for *Communications of the AIS* prior to 2015), questions regarding the nature of the peer review process (which has evolved over time in some journals such as *Communications of the ACM*), or fewer than three Health IS-focused articles.

[4] The advanced search query used on Web of Science is: TS=(healthcare OR health care OR health OR health-care OR medical OR medicine OR clinical OR hospital OR physician OR doctor OR patient OR nurse) AND SO = ("MIS Quarterly" OR "Information Systems Research" OR "Journal of the Association for Information Systems" OR "Journal of Management Information Systems" OR "European Journal of Information Systems" OR "Information Systems Journal" OR "Journal of Information Technology" OR "Journal of Strategic Information Systems" OR "Decision Support Systems" OR "Communications of the Association of Information Systems" OR "Information & Management" OR "Information Systems Frontiers" OR "International Journal of Information Management" OR "Information Systems Management" OR "Information Technology & People" OR "Journal of Computer Information Systems" OR "Information Society" OR "Information and Organization" OR "Management Science" OR "Human Relations" OR "Organization Studies" OR "Organization Science"), where TS means topic and SO denotes publication name.

[5] The data set of Health IS articles was collected in September of 2017.

3.2 Multimethod Data Analysis Procedure

We imported information on Health IS articles exported from Web of Science including authors, year, journal, title, abstract, and reference into a research database. The reference section of an article contains its citation information (all works cited by the article). We parsed the reference section to extract citation information for all Health IS articles and then built an article citation matrix for the Health IS research data set. We then applied an LSA procedure to extract distinct research themes from abstract sections of Health IS articles. Based on the article citation matrix, we calculated the citation matrix at the author level. Citation analysis is based on the assumption that bibliographic references in a paper are a valid indicator of their influence on the citing paper (Cole & Cole, 1972; Ramos-Rodríguez et al., 2004). Thus, repeatedly cited references are thought to be more influential on the intellectual structure of a discipline than less frequently cited articles (Culnan, 1986).

For the data set of the 571 Health IS articles, we conducted two levels of analysis, including research themes and authorship. We employed the LSA procedure used by Sidorova et al.'s (2008) *MIS Quarterly* article to extract the research themes in the extant Health IS literature. Traditional literature reviews manually coded and analyzed by researchers are subject to two substantive limitations: (1) a substantial amount of time and effort necessary to analyze large data sets, and (2) potential researcher bias in coding and analyzing textual data (Larsen, Monarchi, Hovorka, & Bailey, 2008). LSA is a text mining technique that provides another way to unveil hidden concepts from textual data, thereby identifying research themes within large bodies of literature (Evangelopoulos, Zhang, & Prybutok, 2012; Kulkarni, Apte, & Evangelopoulos, 2014; Sidorova et al., 2008). The underlying logic of LSA is that the aggregate of all the word contexts in which a given word does or does not appear provides a set of mutual constraints that largely determines the similarity of meaning of words and sets of words to each other (Landauer, Foltz, & Laham, 1998).

In our application of LSA to the data set of Health IS articles, the LSA procedure extracted distinct research themes from the data set, using a Varimax orthogonal rotation procedure. We explored multiple solutions with 2 to 40 research themes and found a 22-theme solution to be most appropriate to capture meaningful and important factors of Health IS research themes (see Appendices B, C, and D for more details of the LSA procedure, the 22 themes, and representative articles of each theme). Based on the identification of 22 distinct Health IS research themes and article classification into the themes, as well as the article citation information, we created interthematic-level citation relationships and calculated two thematic level measures, including *thematic total citation* and *thematic external citation*. The analysis of authors for the Health IS articles identified 1,236 unique Health IS scholars. To analyze thought leadership in Health IS, we constructed a 1,236 x 1,236 author citation matrix from article level citation relationships by checking the authors of each article.

Next, we used SNA to assess the patterns of article citation within research themes and author-level citation relationship for analyses of the dependence within themes (*thematic intraconnectedness*) and among thought leaders (in-degrees) respectively. We selected SNA for its ability to make inferences about our key constructs as revealed in the citation matrices. SNA can analyze network structures rather than patterns of individual (i.e., node) attributes. Thus, the results of SNA can complement general statistical methods, which generally ignore network structures and topologies. Metrics in SNA such as degree centrality and network density are methodologically mature and hold the potential of analyzing a variety of citation and cocitation relations (Scott & Carrington, 2011).

Generic citation analysis and its close cousin SNA have been employed in prior scientometric-based studies to assess interjournal citation patterns in academic literature. To rank IS journals, Polites and Watson (2009) relied on SNA's ability to disclose the underlying structure of the entire IS discipline. Euske, Hesford, and Malina (2011) investigated the tribalism of management and accounting scholars by analyzing networks of literature citation. Benckendorff (2009) conducted network analysis to reveal themes and trends in tourism research in Australia and New Zealand. In this study, directed graphs unveiled the structure of citation relationships. In our case, the software package NetDraw (Borgatti, 2002) was used to visualize citation relationships.

3.3 Constructs and Measures

To analyze the intellectual structure of Health IS research, we first followed in the footsteps of many related articles that have also employed scientometric approaches (Agarwal, 2016; Culnan, 1987; Kulkarni et al., 2014; Li et al., 2005; Sidorova et al., 2008) by first seeking to uncover the research themes within the Health IS discipline. We identified Health IS research themes as well as distinctions and relationships between them using LSA, citation analysis, and SNA. Table 1 summarizes construct definitions and measures applied.

Table 1. Constructs, Measures, and Analytical Methods

Construct	Definition	Measures used	Primary analytical method
Research themes	Identification of distinct research themes within the Health IS research subdiscipline	LSA factors	LSA
Thematic content cohesion	The extent to which the semantics of Health IS research themes are common across article abstracts	Average intrathematic factor loadings; temporal changes in average loadings	LSA
Thematic total citation	The extent to which research of a theme is cited by articles both inside and outside the research theme	Number of citations cited to articles of a research theme	Citation analysis
Thematic external citation	The extent to which research of a theme is cited by research of other research themes	Number of citations cited to articles of a research theme from outside the theme	Citation analysis
Thematic intra-connectedness	The extent to which articles are integrated via citation within a research theme	Network density of article citation relationship within a research theme	SNA
Thought leadership	Authors demonstrating significant contribution to one or more research themes	In-degree; strength of tie	Citation analysis; SNA; cluster analysis

Notes: LSA stands for latent semantic analysis; SNA stands for social network analysis. Node in-degree and strength-of-tie are centrality metrics in SNA.

Research themes do not appear in a vacuum; they are created and nurtured by scholarly communities. Therefore, we would argue that ideas are not separable from the people who create these ideas and tie their work to other individuals through publication citations. For this reason, we analyzed patterns at the thematic level of Health IS research to uncover how tightly or loosely a community adopts the same linguistic terms in their work (i.e., article descriptors) and how tightly or loosely a community cites itself. Specifically, we analyzed how *cohesive* each of these research themes is by considering *thematic content cohesion* using LSA and *thematic intraconnectedness* using SNA. We defined a theme as having a higher level of thematic content cohesion when terms used in article abstracts within the same theme were more semantically similar than dissimilar. We defined a theme as having a higher level of thematic intraconnectedness if the citation patterns revealed that the articles within a theme were more highly cited by other articles within the same theme. Generally speaking, we used the constructs of *thematic content cohesion* and *thematic intraconnectedness* to measure the extent to which a theme adopts the same linguistic terms and the degree to which a theme cites itself, respectively. We measured the strength of connections between research themes by *thematic external citation*. A higher level of thematic external citation means that the research theme has been highly cited by other research themes, as opposed to being more peripheral in nature (i.e., less cited by other themes).

Finally, we considered *thought leadership*. Thought leadership is an important concept in the study of the intellectual structures of disciplines as well as innovations more generically (Rogers, 1996). The central place of thought leaders in intellectual structures can be traced back to Crane's sociology of science studies (1972) on invisible colleges. Building on de Solla Price's (1963; 1965) emphasis on the importance of citation networks, Crane argued that scientists communicate their ideas through both formal and informal communication channels, which result in ideas that change over time. She asserted that citation networks are a reasonable approximation of how these influences manifest themselves. Crane's views have been largely substantiated by Mulkay, Gilbert, and Woolgar (1975). Both citation patterns and networks can portray which individuals lead these communities of practice (Crane, 1972; de Solla Price, 1963, 1965). We used citation counts (in SNA these are known as node in-degree or centrality measure) to determine which scholars are heading up the intellectual discourse in the overall network of Health IS research (refer to Appendix E for the construction of author citation matrix for SNA). We also delved deeply into Health IS research themes to examine the intellectual leadership within within each Health IS research theme.

4 Results

4.1 Research Themes and Dynamics within Health IS Research

An LSA of Health IS article abstracts using an orthogonal rotation method (Varimax) was best resolved with a 22-factor solution of Health IS research themes. We labeled the themes by checking the high-loading terms and documents associated with each factor.[6] Table 2 summarizes the results. Each of these 22 identified factors represents a unique collection of articles that contain semantically similar terms. The detailed high-loading terms and articles for the 22-factor solution can be found in Appendices C and D. For instance, the research theme F1, which we labeled *Health IS Implementation*, contains articles that similarly use joint terms (in their root forms) such as: project, implement, process, system, and develop. We classified the Health IS research themes (factors) into five overarching categories including: (1) *Health IS Implementation and Investment*, (2) *Health IS Management*, (3) *Clinical Health IS*, (4) *Administrative Health IS*, and (5) *Consumer Health IS*.[7]

We then analyzed the temporal dynamics of Health IS research themes. The dynamics of publication among Health IS research theme categories are shown in Figure 2, aggregated by counting unique articles with significant document-factor loadings[8] (i.e., loading coefficients ≥ 0.0298). The five research theme categories identified had sporadic publications before 1998, while from 1999 to 2005 we see quite a few fluctuations. From 2006 to 2014, publications within most Health IS research theme categories steadily increased with the exception of 2007, which saw a spike in publication within a single year (likely due to the increased interest in EHR adoption and the financial incentives provided by the Meaningful Use legislation that was passed in 2009 and implemented in 2010—see Blumenthal et al., 2010; Jha, 2010). Since 2015, most themes have seen a decreasing publication trend. The waxing and waning of Health IS publications across the years speaks of the extreme volatility of yearly dynamics. Thus, to make more sense of the resulting counts in the subsequent section, we divided the overall range into two periods and conducted further analysis.

We next compared Health IS research theme trends across two separate 14-year time periods: (1) 1990-2003, and (2) 2004-2017, using both percentages of articles per theme in each time period as well as counts of articles per theme in each time period. In terms of percentages of articles published in each research theme in Time Period 1 (1990-2003) vs. Time Period 2 (2004-2017), as depicted in Figure 3, the highest percentage of articles in 1990-2003 were published in: *Health IS Implementation*; *National Health IS Program*; *Health IS Outsourcing, Performance, and Investment*; *Health Image Retrieval and Management*; *Health Analytics and Data Mining; Health IS Acceptance*; *Knowledge Management in Healthcare*; and *Health IS Productivity*. The highest percentage of articles in 2004-2017 were published in: *Health IS Implementation*; *Health IS Acceptance*; *Health IS Outsourcing, Performance, and Investment*; *Online Health Communities and Digital Services*; *Health IS Innovation*; *Health Analytics and Data Mining*; *Knowledge Management in Healthcare*; *EMR and EHR*; *Mobile Health*; and *Health Consumer Privacy*. With regard to trends based on these percentages, research themes in the second time period (2004-2017)—including *Online Health Communities and Digital Services—EMR and EHR*, *Security of Health IS*, *Health Consumer Privacy*, *Health IS Innovation*, *Mobile Health*, *Trust of Health IS*, and *RFID and Tracking in Healthcare* changed most dramatically in terms of popularity (upward trends) while research themes such as *Health IS Acceptance*, *Health IS-Induced Anxiety and Resistance*, *Health IS and Patient-Centered Care*, *Health Information Search and Retrieval*, *Health Information Interchange*, *Knowledge Management in Healthcare*, *Clinical Pathway and Treatment Management*, and *Health IS Compliance* had modest percentage deltas, meaning that publication count percentages were fairly consistent across the two periods for these themes.

[6] As we note in our limitations, the themes were named through a subjective or judgmental process. To mitigate potential bias, we sought to include as many top terms identified by the LSA procedure in the theme names as possible.

[7] Again, as mentioned in the discussion on limitations, these category names were labeled through a subjective or judgmental process. We sought to mitigate potential bias by debating and revising the names between the authors of this study until consensus was reached. We also appreciate and acknowledge the feedback of the anonymous reviewers in refining these research theme category names.

[8] In this analysis of Health IS research themes, we counted articles with document-factor loading coefficients ≥ 0.0298, which is a threshold used to distinguish significant document-factor loadings from insignificant ones (Sidorova et al., 2008). The purpose of such cutoff point decisions is to retain 1/*k* of the loadings for a *k*-factor solution such that each term and document will just load on one factor, on average.

Table 2. Summary of Identified Health IS Research Themes Using LSA

Research theme category*	Factor	Research theme label	Article count
C1. Health IS Implementation and Investment (150 unique articles)	F1	Health IS Implementation	80
	F2	Health IS Acceptance	48
	F3	Health IS-Induced Anxiety and Resistance	2
	F4	Health IS Productivity	10
	F5	Health IS Outsourcing, Performance, and Investment	51
	F6	Health IS Innovation	39
	F7	National Health IS Programs	31
C2. Health IS Management (52 unique articles)	F8	Security of Health IS	21
	F9	Health Information Interchange	6
	F10	Health IS Compliance	13
	F11	Trust of Health IS	13
	F12	Health IS and Patient-Centered Care	2
C3. Clinical Health IS (125 unique articles)	F13	EMR and EHR	28
	F14	Mobile Health	28
	F15	Health Analytics and Data Mining	35
	F16	Health Information Search and Retrieval	14
	F17	Health Image Retrieval and Management	18
	F18	Clinical Pathway and Treatment Management	20
C4. Administrative Health IS (45 unique articles)	F19	Knowledge Management in Healthcare	33
	F20	RFID and Tracking in Healthcare	12
C5. Consumer Health IS (64 unique articles)	F21	Health Consumer Privacy	27
	F22	Online Health Communities and Digital Services	40
*Articles highly loaded to multiple factors are only counted once under each category.			

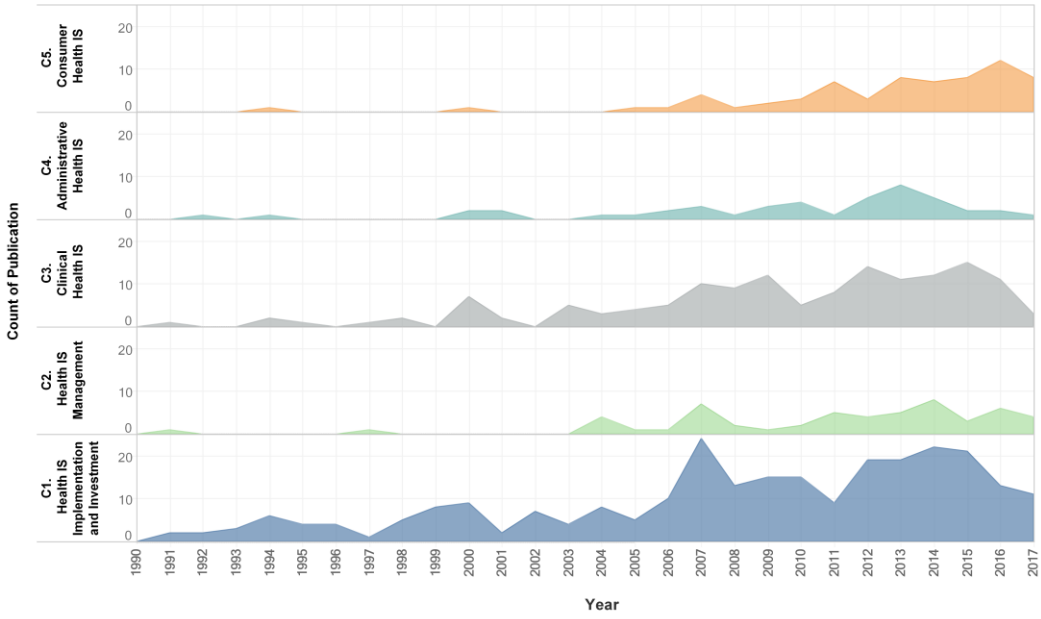


Figure 2. Waxing and Waning of Health IS Research Theme Categories

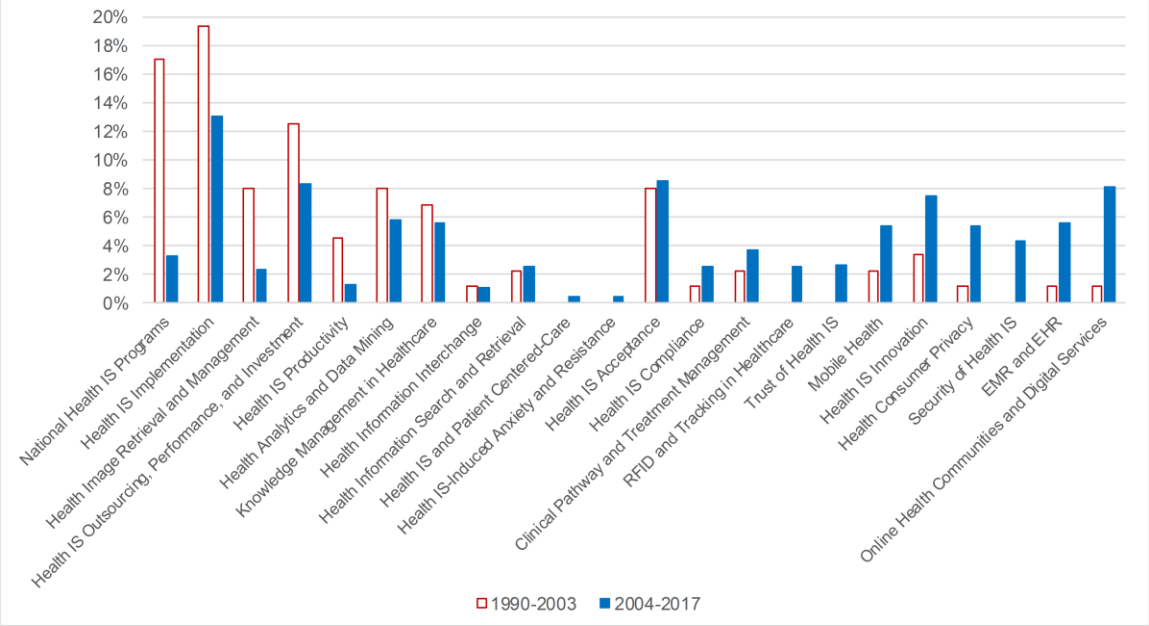


Figure 3. Percentages of Health IS Articles Per Research Theme in 1990-2003 vs. 2004-2017

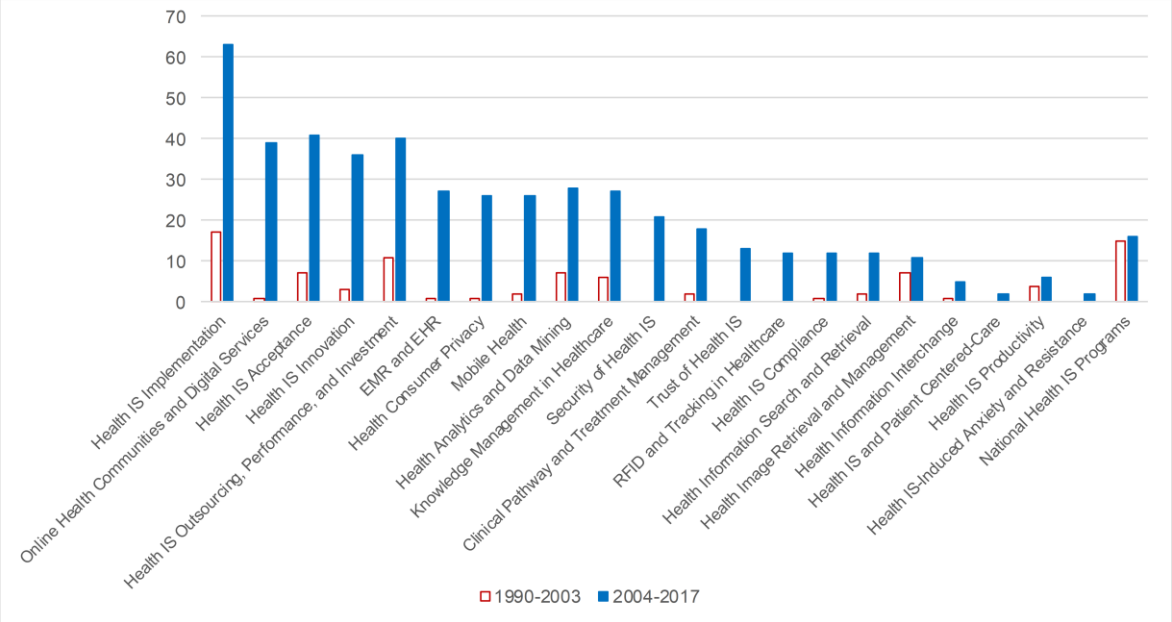


Figure 4. Counts of Health IS Articles Per Research Theme in 1990-2003 vs. 2004-2017

In terms of raw article counts per research theme across the same two time periods (see Figure 4), *Health IS Implementation* saw the largest number of publications in the second period, followed by *Health IS Acceptance*; *Health IS Outsourcing, Performance, and Investment*; *Online Health Communities and Digital Services*; *Health IS Innovation*; *Health Analytics and Data Mining*; *EMR and EHR*; *Knowledge Management in Healthcare*; *Health Consumer Privacy*; *Mobile Health*; and *Security of Health IS*. The areas least studied in the most recent time period (based on raw article counts) were, in descending order, *Health IS and Patient-Centered Care*, *Health IS-Induced Anxiety and Resistance*, *Health Information Interchange*, and *Health IS Productivity*. Overall, the volume of articles published in the second time period in every theme was greater than the corresponding number of articles in the first time period, suggesting a growing research discipline in all themes of research.

4.2 Content Cohesion of Health IS Research Themes

Table 3 shows the *thematic content cohesion* of these 22 Health IS research themes. We distinguish this form of cohesion from thematic intraconnectedness, which will be examined along with thematic external citation in the following subsection. Thematic content cohesion of a research theme is measured as the average loading of articles belonging to the research theme. A higher level of content cohesion of a specific theme means articles within the theme share common semantics or terminology in describing their research topic.

Among the 22 Health IS research themes, (1) *Health IS-Induced Anxiety and Resistance*, (2) *Health IS and Patient-Centered Care*, (3) *Health Information Interchange*, (4) *RFID and Tracking in Healthcare*, (5) *Trust of Health IS*, (6) *Health IS Productivity*, (7) *Health Information Search and Retrieval*, and (8) *Security of Health IS* have the highest average factor-document loadings (i.e., ≥ 0.080). This suggests that these eight research themes are the most "content cohesive" in that they have the highest level of semantic commonality. Research themes including (1) *Online Health Communities and Digital Services*, (2) *Clinical Pathway and Treatment Management*, (3) *Health Analytics and Data Mining*, (4) *Health IS Innovation*, (5) *Health IS Acceptance*, (6) *Mobile Health*, (7) *Health IS Outsourcing, Performance, and Investment*, and (8) *Health IS Implementation* have the lowest average factor-document loadings (i.e., <= 0.051). This indicates that these eight themes are, at the present time, the least semantically consistent and, therefore, exhibit low levels of thematic content cohesion. We noticed that less published themes tend to be more content cohesive (the Pearson correlation between thematic content cohesion and percentage of articles is -0.640, p-value < 0.01). As more research is conducted, the set of key terms used to describe the research may become more diversified, thus diluting the content cohesion of a research theme. However, we argue that this reflects the natural progress of research themes splitting or merging as they require more in-depth scientific exploration.

Table 3. Content Cohesion of Health IS Research Themes from 1990 to 2017

	Factor	Label	Avg. loading of articles	% of articles
High content cohesion	F3	Health IS-Induced Anxiety and Resistance	0.270	0.35%
	F12	Health IS and Patient-Centered Care	0.192	0.35%
	F9	Health Information Interchange	0.104	1.05%
	F20	RFID and Tracking in Healthcare	0.099	2.10%
	F11	Trust of Health IS	0.095	2.28%
	F4	Health IS Productivity	0.093	1.75%
	F16	Health Information Search and Retrieval	0.089	2.45%
	F8	Security of Health IS	0.083	3.68%
Moderate content cohesion	F17	Health Image Retrieval and Management	0.069	3.15%
	F10	Health IS Compliance	0.068	2.28%
	F13	EMR and HER	0.064	4.90%
	F21	Health Consumer Privacy	0.063	4.73%
	F19	Knowledge Management in Healthcare	0.058	5.78%
	F7	National Health IS Programs	0.057	5.43%
Low content cohesion	F22	Online Health Communities and Digital Services	0.051	7.01%
	F18	Clinical Pathway and Treatment Management	0.050	3.50%
	F15	Health Analytics and Data Mining	0.050	6.13%
	F6	Health IS Innovation	0.050	6.83%
	F2	Health IS Acceptance	0.049	8.41%
	F14	Mobile Health	0.047	4.90%
	F5	Health IS Outsourcing, Performance, and Investment	0.043	8.93%
	F1	Health IS Implementation	0.040	14.01%

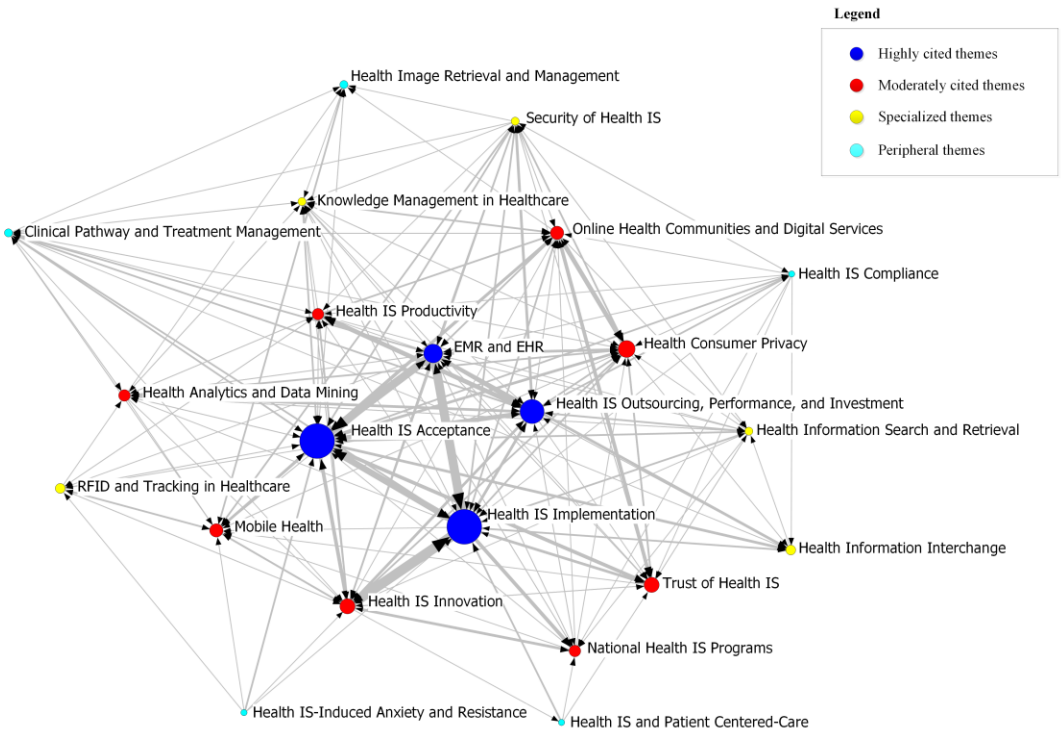


Figure 5. Citation Relationships Between Health IS Themes (1990-2017)

4.3 Thematic Citation of Health IS Research Themes

We then analyzed the citation relationships between Health IS research themes to help reveal those themes that are cited most frequently in the overall scholarly discourse and that have the greatest influence on the intellectual structure of the Health IS community. The thematic total citation is measured by the number of citations directly cited to articles of a research theme from articles both inside and outside the research theme. The citation relationships between the 22 Health IS research themes are shown in Figure 5. The size of each node is proportional to the number of citations a theme received, while thickness of the arrows and lines represents the relative strength of the citation relationship between any two themes.

Based on this citation relationship analysis, we classified the 22 research themes into four groups, ordered according to total citations received (as shown in parentheses).

- **Group 1. Frequently cited themes**
  - F2: Health IS Acceptance (230 citations)
  - F1: Health IS Implementation (229 citations)
  - F5: Health IS Outsourcing, Performance, and Investment (148 citations)
  - F13: EMR and EHR (104 citations)
- **Group 2. Moderately cited themes**
  - F21: Health Consumer Privacy (85 citations)
  - F6: Health IS Innovation (75 citations)
  - F11: Trust of Health IS (75 citations)
  - F22: Online Health Communities and Digital Services (64 citations)
  - F14: Mobile Health (54 citations)
  - F4: Health IS Productivity (42 citations)
  - F7: National Health IS Programs (37 citations)
  - F15: Health Analytics and Data Mining (37 citations)
- **Group 3. Infrequently cited themes (specialized)**
  - F9: Health Information Interchange (29 citations)
  - F20: RFID and Tracking in Healthcare (27 citations)
  - F19: Knowledge Management in Healthcare (22 citations)
  - F16: Health Information Search and Retrieval (20 citations)
  - F8: Security of Health IS (19 citations)

- **Group 4. Very infrequently cited themes (peripheral)**
  - F18: Clinical Pathway and Treatment Management (15 citations)
  - F17: Health Image Retrieval and Management (14 citations)
  - F10: Health IS Compliance (6 citations)
  - F3: Health IS-Induced Anxiety and Resistance (1 citation)
  - F12: Health IS and Patient-Centered Care (1 citation)

What does this citation analysis suggest at the thematic level? Except for Group 4 (peripheral themes), which shows few citations from other Health IS themes, a high percentage of works cite the literature of *Health IS Acceptance*; *Health IS Implementation*; *Health IS Outsourcing, Performance, and Investment*; and *EMR and EHR*. What appears to be the case is that these citations by scholars are used, in many cases, to motivate their own work. To a lesser extent, they also cite the *Health Consumer Privacy*, *Health IS Innovation*, *Trust of Health IS*, *Online Health Communities and Digital Services*, *Mobile Health*, *Health IS Productivity*, *National Health IS Programs*, and *Health Analytics and Data Mining* literature. Group 3 (specialized themes) contains specialized areas that are not highly cited in the citation patterns, no doubt due to their tighter focus on more specific aspects of Health IS. *Health Information Interchange*, and *Health Information Search and Retrieval* are good examples of this kind of niche research. Lower numbers of received citations do not necessarily reflect poorly on the work; they simply reflect the amount of general Health IS interest in niche themes.

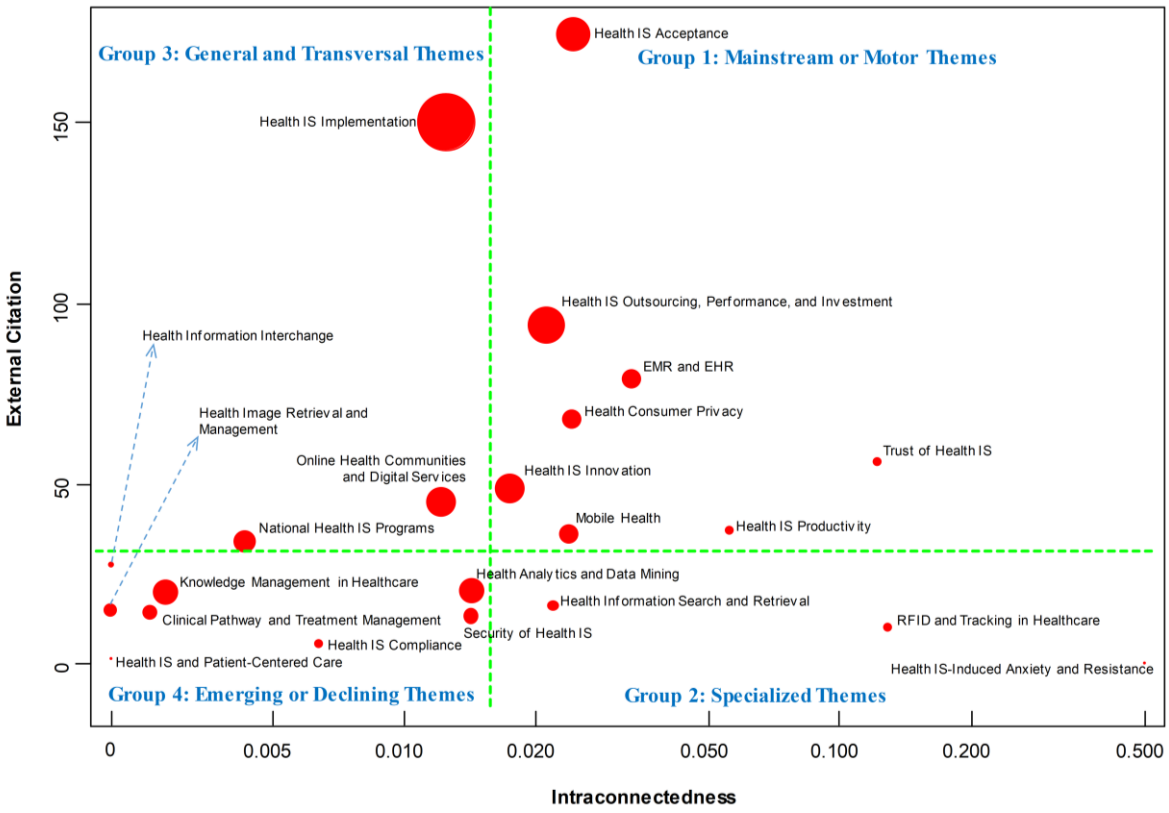
Next, to compare the inter- and intra-impacts of all thematic groups, we assessed the combined impact of *thematic external citation* and *thematic intraconnectedness* for each Health IS theme. Thematic external citation is measured by the total number of citations that research related to a specific theme receives from research related to other themes. Thematic external citation indicates the extent to which research in one theme influences other Health IS themes. Thematic intraconnectedness is measured by the density of the directed citation network of articles within each theme, which is the ratio of all present citation relationships to all possible ties (Hanneman & Riddle, 2005) using the following formula:

$$Density = \frac{C}{N * (N - 1)}$$

where C is the number of citation relationships between articles within the theme, and N is the number of articles in the theme. For instance, the theme *EMR and EHR* contains 25 citations across 28 articles within the theme, thus its thematic intraconnectedness (network density) is 25/(28*(28-1)) = 0.033. A higher network density indicates a higher connectedness and mutual influence of articles within a theme. We adapted the strategic diagram used for coword analysis of research themes to give a synthetic and simplified representation of research themes according to their internal connectedness and external interaction with other themes (Callon, Courtial, & Laville, 1991; Delecroix & Epstein, 2004). As shown in Figure 6, we compared the 22 research themes by their thematic external citation and thematic intraconnectedness (density) and divided them into four quadrants by medians of the two measures.

Clearly, *Health IS Acceptance*, *Health IS Outsourcing, Performance, and Investment*, *EMR and EHR*, *Health Consumer Privacy*, *Trust of Health IS*, *Health IS Innovation*, *Health IS Productivity*, and *Mobile Health* in Group 1 (high intraconnectedness, high external citation) are frequently cited by other themes and have a relatively high citation level within their own themes. These eight mainstream or motor themes represent the current focus of Health IS. In particular, *Trust of Health IS* has been highly recognized and influential within and outside its own theme, even though it contains a relatively small number of publications (13 articles). By contrast, Group 2 (high intraconnectedness, low external citation) is composed of three specialized research themes including *Health Information Search and Retrieval*, *RFID and Tracking in Healthcare*, and *Health IS-Induced Anxiety and Resistance*. These themes have high intraconnectedness within themselves, but outside citations are relatively sparse. This suggests that studies of these three narrowly focused research themes, although well recognized within their own themes, do not receive high levels of recognition from other themes. In addition, these three themes have not been well explored by Health IS scholars, as there are just a few articles published (ranging from 2 articles for *Health IS-Induced Anxiety and Resistance* to 14 articles for *Health Information Search and Retrieval*).

Three general and transversal themes, including *Health IS Implementation*, *Online Health Communities and Digital Services*, and *National Health IS Programs* in Group 3 (low intraconnectedness, high external citation) have been widely recognized or cited by other themes, but exhibit lower density of intrathematic citations. This reveals that research in this thematic group tends to be cited by and thus provide intellectual basis for other research outside of the theme, as these themes focus on general and broad topics across multiple specialty areas of Health IS.



Notes:
The size of each circle is proportional to the number of articles in the theme.
X-axis has been log transformed to deal with the skewed distribution of intraconnectedness.
Vertical and horizontal green dashed lines represent medians of intraconnectedness and external citations respectively.

Figure 6. Strategic Diagram: Inter- and Intra-Impacts of Research in Health IS Themes

It is also evident that Health IS research themes in Group 4 (low intraconnectedness, low external citation) including *Health Information Interchange*, *Health Analytics and Data Mining*, *Knowledge Management in Healthcare*, *Clinical Pathway and Treatment Management*, *Health Image Retrieval and Management*, *Security of Health IS*, *Health IS Compliance*, and *Health IS and Patient-Centered Care* are closer to the point of origin in Figure 6, meaning that they are emerging or declining themes loosely coupled with other structural components of the field of Health IS research. These themes are less developed thematic domains that have yet to mature in that citation patterns remain fragmented (and tend to consolidate as a research domain becomes older and more centralized), but early research themes often exhibit such variation as a discipline evolves. Such variation allows for an evolutionary selection process that often enhances the movement toward a strong paradigm. Thus, such variation is a good sign of early exploration and growth, but, if these areas are to move toward maturity, we later argue these themes will eventually need more directive leadership so that future research can better support these less central and less cohesive themes.

We also noticed that themes with higher levels of content cohesion tend to have higher levels of intraconnectedness (the Pearson correlation between thematic content cohesion and thematic intraconnectedness is 0.778, p-value < 0.01) and be less cited by research of other themes (the Pearson correlation between thematic content cohesion and thematic external citation is -0.427, p-value < 0.05). As research themes consolidate their content semantics and use of key terms, they tend to cite existing research within the same thematic group. However, highly content-cohesive research themes may too narrowly focus on specialized topics and would thus not be widely recognized by other thematic groups.

4.4 Thought Leadership in Health IS

Up to this point, we have primarily discussed key Health IS research themes and relationships between the identified themes. We now turn our attention to *thought leadership*, with a particular emphasis on authors of Health IS research in mainstream IS journals.

We begin with some general descriptive statistics that tell us a great deal about the makeup of the thought leadership in this domain. Our data set of Health IS articles contains 1,236 unique authors in total, with most authors publishing fewer than two articles—specifically, 82.9% of authors published only one Health IS study and 10.6% of authors published two articles. The most prolific authors (with three or more publications) represent 6.5% of the author pool.[9] This finding is consistent with studies conducted in other disciplines such as management control (e.g., Euske et al., 2011). It is also quite consistent with the power distributions uncovered by Chua, Cao, Cousins, and Straub (2002) across baskets of 4 to 58 IS journals. This also means that a small group of authors constitute the thought leaders of the field and that the burden of further developing the field falls heavily on their shoulders.

After filtering out 598 authors without any citations from all of the Health IS articles (authors not cited at least once were not included, as a minimum of one citation is required to connect two nodes), we analyzed a data set of 638 Health IS scholars. To categorize all the Health IS scholars according to in-degrees, we obtained a 4-cluster solution by using a k-means clustering algorithm:

Cluster 1: Kohli, R.; Agarwal, R.

Cluster 2: Devaraj, S.; Davidson, E.; Angst, C.; Hu, P. J.; Lapointe, L.; Rivard, S.; Menon, N. M.; Chau, P. Y. K.; Gao, G. D.; Aanestad, M.; and Braa, J.

Cluster 3: Lee, B.; Sheng, O. R. L.; Jensen, T. B.; Mathiassen, L.; Monteiro, E.; Sahay, S.; DesRoches, C.; Jha, A. K.; another 45 authors

Cluster 4: 572 remaining scholars

To further explore the citation relationships between Health IS research thought leaders and scholars, we zoomed in on one end of the distribution by showing only scholars with an in-degree ≥ 20 and citation strength-of-tie ≥ 3, as depicted in Figure 7. This simplified network displays the 58 most frequently cited Health IS scholars in the first three clusters. The figure clearly shows that several scholars dominate the citation structure with four small outlying clusters of citation relationships among small, isolated cliques. The top 24 most highly cited Health IS scholars are revealed in Table 4 with their rankings.

These scholars (see Figure 7) represent the intellectual thought leaders of Health IS research in the IS field. Given the network centrality demonstrated by the in-degree citations, these scholars have been setting the direction for Health IS research. However, thought leadership is often focused on particular themes and, in recognition of this observation, we also analyzed thought leadership according to Health IS research theme. A more detailed list of top Health IS scholars by research theme can be found in Appendix G. This analysis provides more granular insights into the primary contributors and influencers of each research theme, hopefully giving current and future researchers a better idea of which authors to search for when seeking seminal and influential articles to cite and build upon in their own work.

4.5 Relationship Between Health IS and Reference Fields

As an interdisciplinary field, Health IS research has drawn theoretical perspectives from many disciplines such as IS, management, health informatics, computer science, and psychology to study the applications of information technology in various health- and medicine-related settings. By analyzing the journals cited by Health IS articles, we can reveal the citation relationships between Health IS research and its reference disciplines. In total, we identified 131 journals that have been cited at least 20 times by the 571 Health IS articles in our data set. Then we classified the 131 journals into 18 disciplines based on the Thomson Reuters Journal Citation Report (JCR) journal categories and aggregated the citations into the disciplinary level by sum. The summary information of the 131 journals can be found in Appendix H. We present the influence of reference disciplines on Health IS research in Figure 8, where the size of each node is proportional to the number of citations that a field or journal has received from the 571 Health IS articles. Clearly, *information systems* (6083 citations) and *management* (3684 citations) dominate in the reference disciplines of Health IS research, as much of Health IS research originates from business or information schools rather than from institutions with a clinical emphasis (i.e., academic medical centers, schools of public health, etc.). This is consistent with the finding by Polites et al. (2009) on the intellectual structure of IS that management, operations research, and management science are major contributors to the IS discipline. Other major contributing disciplines are *health informatics* (1368 citations), *computer science* (1052 citations), *medicine* (1010 citations), and *health service* (455 citations). This suggests that health informatics, computer science, and health- and medicine-related fields are key drivers of knowledge creation in this space, but not the dominant bases of Health IS research.

[9] A summary of author productivity can be found in Appendix F.

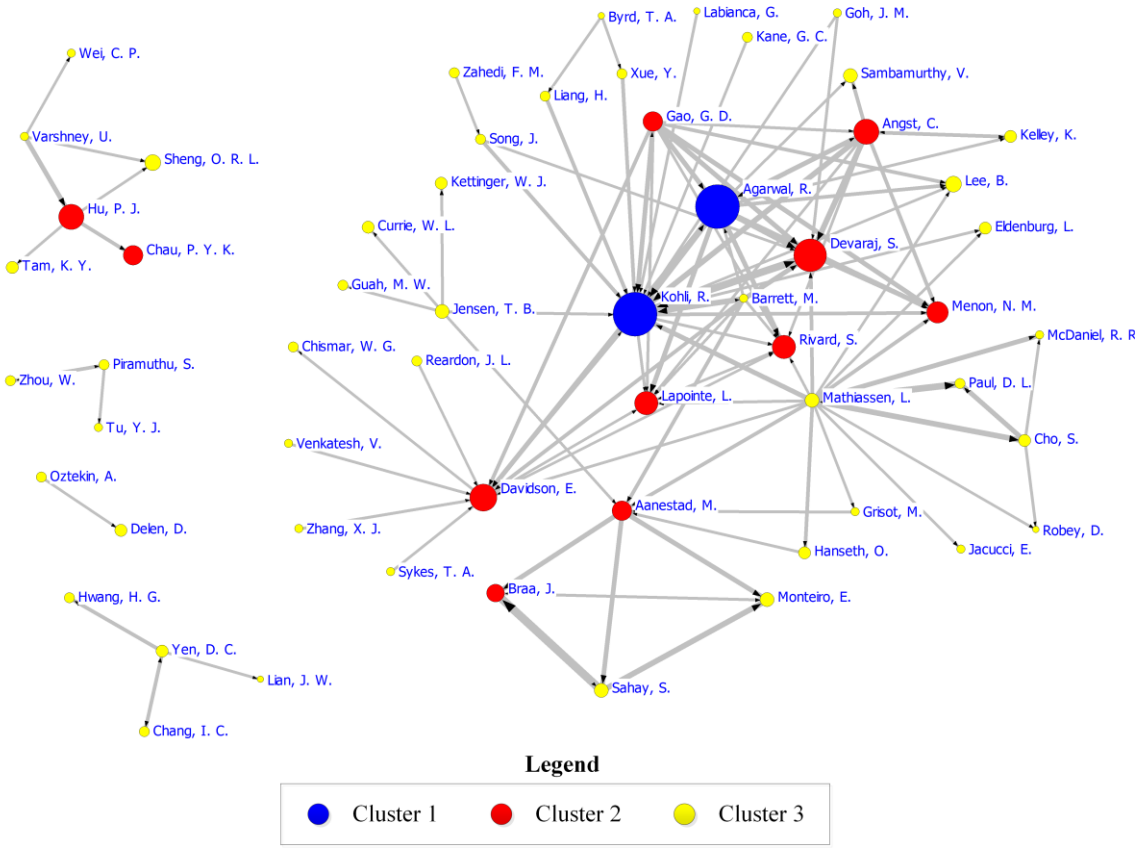


Figure 7. Frequently Cited Health IS Authors (Top 58 Scholars, In-Degree ≥ 20, Strength-of-Ties ≥ 3) [10]

Table 4. Top Health IS Scholars According to In-Degree Citation Counts

Rank	Author	In-degree		Rank	Author	In-degree
1	Kohli, R.	301		12	Braa, J.	102
2	Agarwal, R.	294		13	Lee, B.	93
3	Devaraj, S.	210		14	Sheng, O. R. L.	89
4	Davidson, E.	174		15	Jensen, T. B.	82
5	Angst, C.	162		16	Mathiassen, L.	81
6	Hu, P. J.	157		17	Monteiro, E.	79
7	Lapointe, L.	148		17	Sahay, S.	79
7	Rivard, S.	148		18	DesRoches, C.	73
8	Menon, N. M.	127		18	Jha, A. K.	73
9	Chau, P. Y. K.	120		19	Sambamurthy, V.	70
10	Gao, G. D.	118		20	Currie, W. L.	69
11	Aanestad, M.	114		21	Hanseth, O.	68

[10] Showing all ties in the diagram would lead to insuperable difficulties in interpreting the network structure. To simplify the diagram, only relationships with strength-of-ties equal to or larger than a specific threshold are displayed. Following the approach used by Euske et al. (2011), we iteratively increased the cutoff point to the point where the network structure becomes visually apparent. The interpretability of the network structure at a particular cutoff point strongly suggests the threshold to be used to reveal the social network structure.

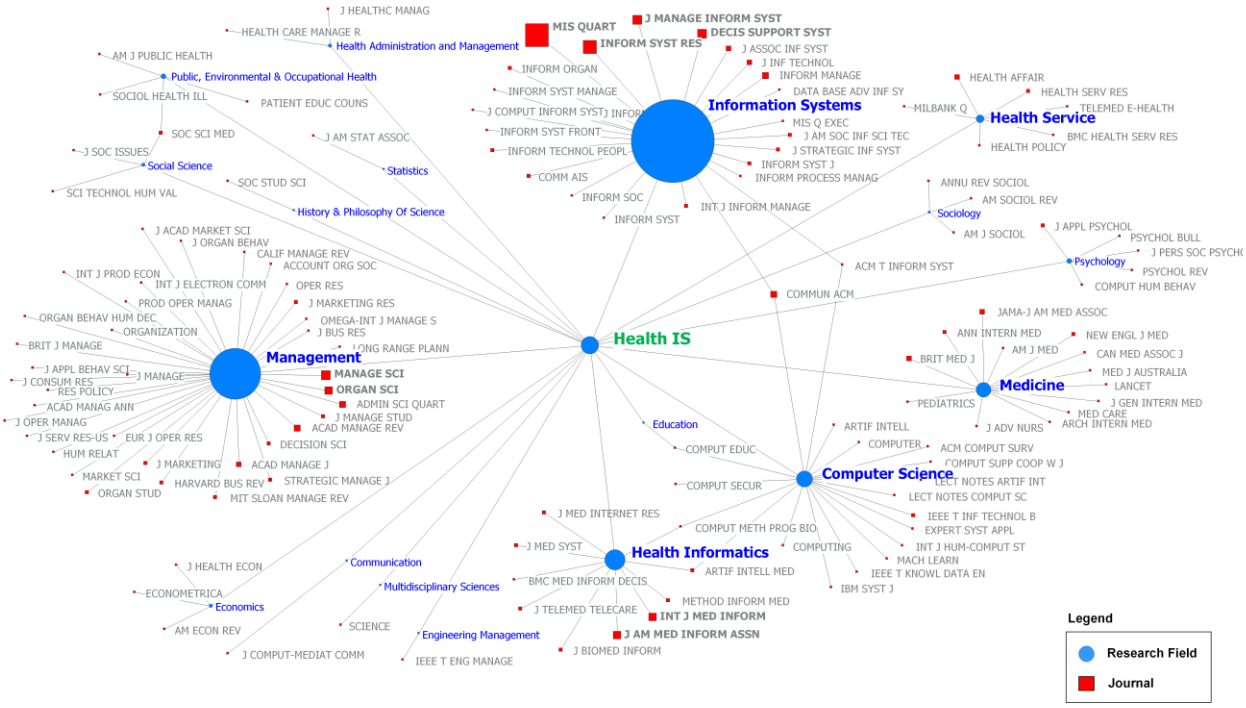


Figure 8. Relationship Between Health IS and Its Reference Research Fields and Journals

The most cited journals by Health IS articles include: (1) *MIS Quarterly* (1579 citations), (2) *Information Systems Research* (816 citations), (3) *Management Science* (553 citations), (4) *Decision Support Systems* (516 citations), (5) *Journal of Management Information Systems* (510 citations), (6) *Organization Science* (436 citations), (7) *Journal of the American Medical Informatics Association* (433 citations), and (8) *International Journal of Medical Informatics* (393 citations).

4.6 Summary of Findings and Identification of Research Opportunities

As summarized in Table 5, we find that the volume of Health IS articles published in mainstream IS journals has increased substantially from the early period of 1990-2003 to the recent period of 2004-2017. The majority of Health IS research has focused broadly on research in the category of *Health IS Implementation and Investment*, which collectively represents 150 unique published articles (26.3% of the total of 571 articles). Particularly, the research themes of *Health IS Implementation*; *Health IS Outsourcing, Performance, and Investment*; *Health IS Acceptance*; and *Health IS Innovation* account for a large part of the Health IS articles published and exhibit high external citation, suggesting a large number of citations from other themes. Interestingly, content cohesion of themes in this category except *Health IS-Induced Anxiety and Resistance* and *Health IS Productivity* ranges from low to moderate, suggesting these themes have not yet matured to the point of using substantially similar semantics.

The unique articles published across the six *Clinical Health IS* themes account for 21.9% (125) of the 571 articles. Interestingly, though, research themes in the *Clinical Health IS* category exhibit generally lower external citation and intraconnectedness than those in *Health IS Implementation and Investment*, suggesting that *Clinical Health IS* research is more peripherally cited in Health IS research in mainstream IS journals, but that it also exhibits moderate to high content cohesion in the *EMR and EHR*, *Health Information Search and Retrieval*, and *Health Image Retrieval and Management* themes, indicating more consistent semantics within these themes. These trends are likely related to the major push for clinical Health IS adoption, as well as questions regarding whether or not investments in such technologies would result in cost savings (or some form of return on investment). This was an especially important topic leading up to and during the US push for EHR adoption via the Meaningful Use program that was passed in 2009 and implemented in 2010, which provides financial incentives to eligible hospitals and clinicians who adopt and exhibit meaningful use of EHRs (Blumenthal et al., 2010; Jha, 2010).

Table 5. Summary of Health IS Research Intellectual Structure Findings

Rsrch. theme cat.	Factor	Research theme label	Total article count	Article count (%) 1990-2003	Article count (%) 2004-2017	Thematic content cohesion	Thematic external citation	Thematic intra-connected-ness	Top thought leaders
Health IS Implementation And Investment (150 unique articles)	F1	Health IS Implementation	80	17 (19.5%)	63 (13.0%)	Low	High	Low	Lapointe, L. Rivard, S. Davidson, E. Chismar, W. G. Sahay, S. Monteiro, E. Aanestad, M. Hanseth, O.
	F2	Health IS Acceptance	48	7 (8.0%)	41 (8.5%)	Low	High	High	Lapointe, L. Rivard, S. Chau, P. Y. K. Hu, P. J. Devaraj, S. Kohli, R. Sheng, O. R. L. Tam, K. Y.
	F3	Health IS-Induced Anxiety and Resistance	2	0 (0.0%)	2 (0.4%)	High	Low	High	Bick, M. Kummer, T. F. Ryschka, S.
	F4	Health IS Productivity	10	4 (4.6%)	6 (1.2%)	High	High	High	Menon, N. M. Lee, B. Eldenburg, L.
	F5	Health IS Outsourcing, Performance, And Investment	51	11 (12.6%)	40 (8.3%)	Low	High	High	Kohli, R. Devaraj, S. Menon, N. M.
	F6	Health IS Innovation	39	3 (3.4%)	36 (7.4%)	Low	High	High	Mathiassen, L. Agarwal, R. Angst, C. Kelley, K. Sambamurthy, V.
	F7	National Health IS Programs	31	15 (17.2%)	16 (3.3%)	Moderate	High	Low	Currie, W. L. Guah, M. W.
Health IS Management (52 unique articles)	F8	Security of Health IS	21	0 (0.0%)	21 (4.3%)	High	Low	Low	Kankanhalli, A. Ng, B. Y. Xu, Y. J.
	F9	Health Information Interchange	6	1 (1.1%)	5 (1.0%)	High	Low	Low	Bhattacherjee, A. Hikmet, N.
	F10	Health IS Compliance	13	1 (1.1%)	12(2.5%)	Moderate	Low	Low	Johnston, A. C. Shropshire, J. Warkentin, M.
	F11	Trust of Health IS	13	0 (0.0%)	13 (2.7%)	High	High	High	Zahedi, F. M. Song, J. McDaniel, R. R. Paul, D. L.
	F12	Health IS and Patient-Centered Care	2	0 (0.0%)	2 (0.4%)	High	Low	Low	Klecun, E.

Table 5. Summary of Health IS Research Intellectual Structure Findings

Clinical Health IS (125 unique articles)	F13	EMR and EHR	28	1 (1.1%)	27 (5.6%)	Moderate	High	High	Agarwal, R. Angst, C. Davidson, E. Aanestad, M. Jensen, T. B. Reardon, J. L.
	F14	Mobile Health	28	2 (2.3%)	26 (5.4%)	Low	High	High	Varshney, U. Sarker, S. Sneha, S.
	F15	Health Analytics and Data Mining	35	7 (8.0%)	28 (5.8%)	Low	Low	Low	Aron, R. Dutta, S. Janakiraman, R. Pathak, P. A. Delen, D.
	F16	Health Information Search and Retrieval	14	2 (2.3%)	12 (2.5%)	High	Low	High	Chen, H. C. Barrett, M. Kohli, R. Qin, J. L. Salge, T. O. Zhou, Y. L.
	F17	Health Image Retrieval and Management	18	7 (8.0%)	11 (2.3%)	Moderate	Low	Low	Hu, P. J. Sheng, O. R. L. Wei, C. P.
	F18	Clinical Pathway and Treatment Management	20	2 (2.3%)	18 (3.7%)	Low	Low	Low	Bardhan, I. Kirksey, K. Oh, J. H. Zheng, Z. Q.
Administrative health IS (45 unique articles)	F19	Knowledge Management in Healthcare	33	6 (6.9%)	27 (5.6%)	Moderate	Low	Low	Paul, D. L. Chang, N. Hu, P. J. Kallinikos, J. Leidner, D. E. Sheng, O. R. L.
	F20	RFID and Tracking in Healthcare	12	0 (0.0%)	12 (2.5%)	High	Low	High	Piramuthu, S. Zhou, W. Tu, Y. J.
Consumer Health IS (64 unique articles)	F21	Health Consumer Privacy	27	1 (1.1%)	26 (5.4%)	Moderate	High	High	Agarwal, R. Angst, C. Anderson, C. Bansal, G. Gefen, D. Zahedi, F. M.
	F22	Online Health Communities and Digital Services	40	1 (1.1%)	39 (8.1%)	Low	High	Low	Agarwal, R. Varshney, U. Klein, R.

We also find that work in the research theme categories of *Health IS Management*, *Administrative Health IS*, and *Consumer Health IS* is more specialized and peripheral in nature than research in the high-level *Health Implementation and Investment* and *Clinical Health IS* categories. Additionally, we found the research in these categories to have relatively low levels of thematic intraconnectedness (with the exception of *Trust of Health IS*, *RFID and Tracking in Healthcare*, and *Health Consumer Privacy*). However, we know that much recent IS research has begun to focus on these areas—for example, IS research contributing to our understandings of patient engagement (e.g., Baird, Furukawa, & Raghu, 2012), online health communities (e.g., Chen, Baird, & Straub, 2019; Yan, Peng, & Tan, 2015), and quality ratings of physicians (e.g., Gao, Greenwood, Agarwal, & McCullough, 2015). Thus, there is significant opportunity to draw on more peripheral and specialized Health IS research with the goal of developing more widely cited models, findings, and contributions. Additionally, as the boundaries of IS continue to broaden in the business-to-consumer and consumer-to-consumer contexts, findings in more specialized and peripheral areas may be further developed as new central theory bases are identified, and may potentially even disrupt existing theory.

Finally, we also see significant opportunities to contribute to research themes that are currently low in both content cohesion and intraconnectedness—namely, *Health IS Implementation*, *Health Analytics and Data Mining*, *Clinical Pathway and Treatment Management*, and *Online Health Communities and Digital Services*. The lower levels of semantic commonality (content cohesion) and self-citing within these themes (thematic intraconnectedness) suggest that these themes are still *highly varied* in terms of foundational theory bases and which research questions are addressed when researching within these themes. Therefore, future contributions to these emerging or transversal themes of research can grasp the opportunity to work toward consolidation and maturity that may yield new theoretical paradigms of research understandings, explanations, predictions, and prescriptions (drawing from IS theory terms in Gregor, 2006).

5 Discussion

We began this paper by discussing the importance of understanding the intellectual structure of an academic discipline. As academic disciplines grow, expand, and even fracture, so do the research themes and structural dynamics within them. Deeper understanding of the evolving intellectual structures of innovative and contextually interesting disciplines and subdisciplines provides a means to further expand, consolidate, and renew a discipline in a systemic and informed manner, while also theoretically contributing back to coordinate and reference disciplines. Given that the IS field has not had a recent in-depth intellectual structural analysis of Health IS, nor a connection made to its reference disciplines prior to the current study, the present work fills an important research gap.

Our results clearly show that the field of Health IS research has evolved through changes in research themes and the emergence of its thought leaders, as well in connection to its reference disciplines. We contribute by providing insights into research themes, research theme dynamics, and thought leadership in this organically growing subdiscipline of IS. Our results above show what IS scholars have studied in earlier periods versus the present time and thus highlight where the "hot" areas might be for the future.

We also contribute by demonstrating how Health IS research in the IS discipline builds on research in other disciplines. We further contribute to the scientometric domain by incorporating a unique combination of methods that, together, provide an especially comprehensive view of the growth and evolution of Health IS research over time. The multimethodological approach has allowed us to contribute additional insights to IS scholars regarding how future Health IS research may help move the IS domain forward.

Finally, and *very importantly*, with our identification of thought leaders in Health IS research as a whole and within its thematic subcommunities, we offer academic institutions insights into who could lead their efforts to capitalize on health care and IS initiatives. Our research thus also identifies people who, we trust, should take it upon themselves to lead the community as a whole and the specialty areas in innovating via conference tracks, special journal issues, and special interest groups. This alone, we believe, is a significant contribution to what we know about the current state of Health IS.

In regard to what these results mean to IS researchers, they demonstrate where prior research has been focused and provide valuable information for future Health IS research project decision-making. For instance, we find that four themes are currently central to Health IS research (see Figure 5 for more details): (1) *Health IS Acceptance*, (2) *Health IS Implementation*, (3) *Health IS Outsourcing, Performance, and Investment*, and (4) *EMR and EHR*. These findings suggest that much of the core of Health IS research centers on how health care organizations invest in and then assimilate Health IS such as EMRs and EHRs. Making a contribution within this core will require approaches that both build upon this well-established research and carve out enough of a niche to contribute, which carries the risk of either only incrementally contributing or needing to find novel enough situations (or Health IS artifacts) to make a

significant contribution. On the other hand, making a contribution at the periphery potentially carries a higher risk of not sufficiently contributing to core Health IS theories, but also potentially more reward as advances at the periphery may require novel approaches that are less informed by prior research and, thus, help to blaze paths toward new theory building. As a tradeoff between these two ends of the contribution spectrum, we note that themes such as *Health Analytics and Data Mining*, *Mobile Health*, *Health Information Interchange*, and *Online Health Communities and Digital Services* seem to offer significant opportunities for future research, without being too far away from the core, and thus may provide a reasonable balance between these risks and rewards. Finally, we note that the opportunity to use Health IS research as a bridge between management and IS research seems particularly fruitful. As shown in Figure 8, while Health IS research has a strong relationship with many disciplines, the relationship is particularly strong with management and IS journals. Therefore, this means that IS researchers can potentially leverage the Health IS research context to further our understanding of the intersection of management and IS theories, particularly in cases where health care provides new understandings or further nuance to prior theorizing.

In regard to moving forward, we contribute a basis that future research can leverage to create a more complete understanding of the field as considerations are made regarding how we might best continue to contribute to the Health IS research subdiscipline (and integrate it with other fields). In particular, research is needed to move this field forward with insights into how usable and timely IS can be implemented in a health care industry that is constantly seeking a tricky balance between consumer and producer welfare, as well as between many sometimes competing and sometimes cooperating stakeholders. Further, the outstanding capabilities of Health IS research can be used in conjunction with individual and collective skills and abilities to deliver the best possible outcomes at the lowest possible cost in new and novel forms that will cut across and shift traditional boundaries. While the diversity and volume of health information is drastically increasing, the value of the information is greatly diminished if it is not available in usable form when and where it is needed. Right now, while IS use in health care has been noted to be valuable and have substantial additional potential, the backlash against systems that are difficult to use or replete with incomplete information is growing (e.g., Kellermann & Jones, 2013). Further, it has been predicted that the number of hospitals, which are where much of the current Health IS research efforts are often focused, will be drastically reduced as technology reshapes the industry with access points via telehealth and small regional organizations that provide more targeted services, rather than the duplication of services we now see in many competing hospital systems (Wachter, 2015). Overall, our analyses identifying Health IS research leaders and thematic foci provide implications for the individuals and methods likely to be involved in developing the current intellectual structures of Health IS research, contributing to further growth and evolution, and shaping the future of the health care industry.

We note that our research is constrained by: (1) limitations of methods, (2) limitations of data collection (e.g., time frame and reliance on Web of Science), (3) limitations in the set of journals we focused on (i.e., perhaps a larger sample could be considered in the future and compared to our results), (4) limitations in naming of the research categories and themes, and (5) limitations in inference and generalization. In particular, we note that our data set of Health IS articles does not consist of a population, but rather a sample and, therefore, the inferences generated in this study are limited by the size and scope of our sample as well as by the methods applied toward analysis. We also note that the names of the research themes and theme categories, while based to the extent possible on objective information, including the root words extracted by the LSA process, were labeled through a subjective or judgmental process and could be named differently (or interpreted differently) by different researchers. Further, we note that our results may be biased, as discussed in more detail by Moher, Liberati, Tetzlaff, Altman, and The PRISMA Group (2009), by publication bias associated with "selective reporting of completed studies" and variation in the quality of data used in each of the studies we included in our sample, without an evaluation of whether the quality is higher in some studies than others. Even with such limitations, we believe our analyses, findings, and interpretations offer interesting insights into the development and evolution of this growing research field.

Future research on the intellectual structure of Health IS research could address these limitations by: (1) expanding the time frame of analysis as time progresses and as research trends evolve, (2) delving deeper into the themes identified in our analyses for further and more fine-grained insights, (3) applying new and novel scientometrically based methods to the content of published articles and relationships between articles, and (4) considering how other variables of interest may play a role in Health IS research, including funding sources for studies and the role of sponsorship and data set availability on research topic focus.

6 Conclusion

We have extended prior work by contributing multimethod intellectual structure analyses that span

more than two decades of Health IS research in mainstream IS journals and have provided an intellectual basis for how this research connects to its reference disciplines. We follow in the footsteps of notable prior intellectual structure analyses in the IS discipline (e.g., Culnan, 1986, 1987; Polites et al., 2009; Sidorova et al., 2008) and in health informatics (e.g., Raghupathi et al., 2010; Schuemie et al., 2009). We specifically contribute by providing insights into research themes and thought leadership in this organically growing research field, especially from the point of view of IS scholars.

This is an exciting time in the IS discipline and we are optimistic about the plethora of Health IS research projects that have already been carried out as well as those that will be conducted in years to come. We take a natural step to instantiate this optimism by providing insights into potential future directions of Health IS research that should continue to enhance the depth and breadth of Health IS research within IS journals. In conclusion, we encourage current and future Health IS researchers alike to recognize how they are contributing to the intellectual structures that will systematically consolidate, expand, and renew the Health IS knowledge base.

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Appendix A: Health IS Article Selection

Table A1 shows the number of articles identified for mainstream IS journals.

Table A1. Journal Selection

Mainstream IS journals (in order of retrieved article count)	# of retrieved articles	Citations of retrieved articles	# of total publications indexed by Web of Science	Acceptance rate of health IS Research (%)
Decision Support Systems	140	2,608	2,627	5.33
International Journal of Information Management	56	602	1,197	4.68
European Journal of Information Systems	41	886	765	5.36
Information & Management	39	991	1,582	2.47
Information Systems Frontiers	33	226	761	4.34
MIS Quarterly	32	1,495	834	3.84
Information Systems Research	31	630	783	3.96
Journal of Management Information Systems	28	1,445	669	4.19
Journal of the Association for Information Systems	26	257	331	7.85
Journal of Information Technology	26	412	558	4.66
Information Technology & People	18	82	212	8.49
Information Systems Management	17	155	785	2.17
Journal of Strategic Information Systems	15	67	378	1.21
Journal of Computer Information Systems	14	372	1,242	3.70
Information Systems Journal	11	222	467	2.36
Communications of the Association for Information Systems	9	9	124	7.26
Management Science	9	601	3,712	0.24
Information Society	8	136	479	1.67
Information and Organization	7	21	125	5.60
Human Relations	5	155	1,685	0.30
Organization Studies	3	118	1,281	0.23
Organization Science	3	100	1,413	0.21
Total	**571**	**11,590**	**22,010**	

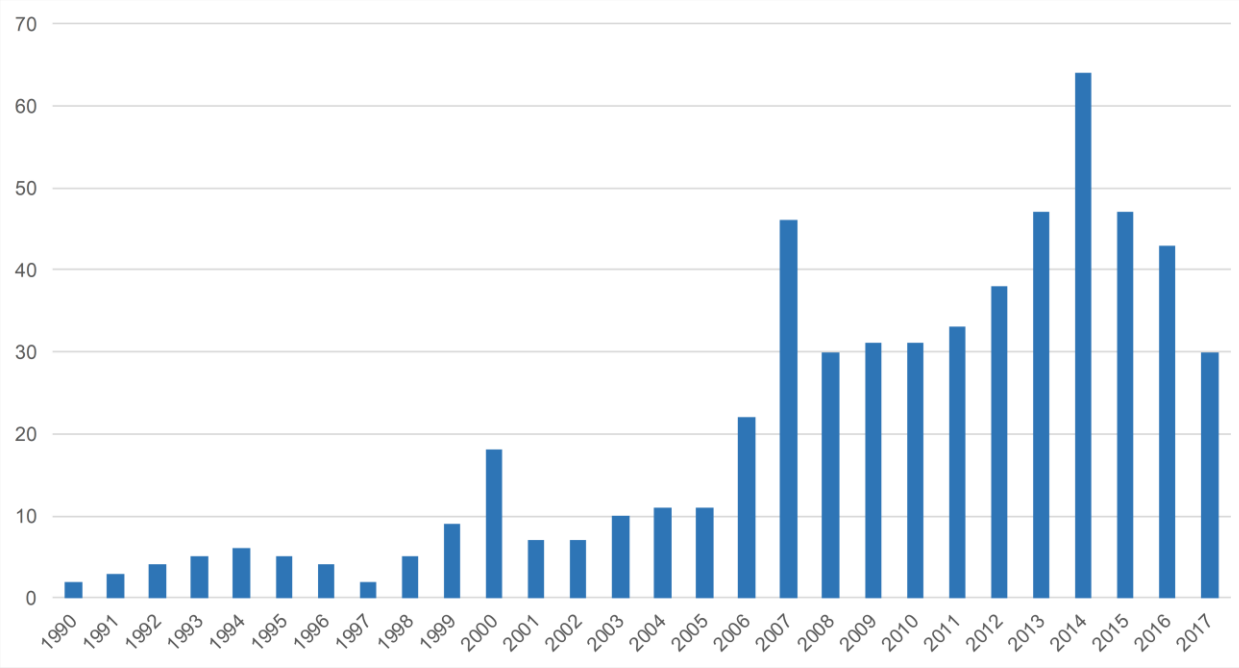

Figure A1. Health IS Yearly Publication Counts (As of August 2017)

Appendix B: Latent Semantic Analysis Procedure

Latent semantic analysis (LSA) was initially proposed as an information indexing and retrieval approach based on conceptual content rather than exact match of inquiry words (Deerwester, Dumais, Furnas, Landauer, & Harshman, 1990). Following the similar LSA procedure used by Sidorova et al. (2008), we systematically analyzed the research themes of Health IS via the following procedure:

Step 1. Text Preprocessing and Term Reduction

Abstracts were extracted from all existing articles. Then the abstracts were tokenized by filtering out nonletter characters. Stop words such as "the," "this," "a," etc. were filtered out since they only have trivial meaning in English. All tokens with just one letter (such as "c," "d," "e," etc.) were also removed. After transferring all tokens into lower case, the Porter stemming algorithm (Porter, 1980) was used to remove term suffices. For example, tokens such as "collaborate," "collaborating," "collaboration," and "collaborative" were replaced by their common stem "collabor." Finally, terms with only one occurrence were also filtered out since they did not load to more than two documents and were trivial to LSA. As a result, we obtained 2,386 terms. Figure B1 shows a word cloud of the 150 most frequently used terms in Health IS research.

Figure B1. Word Cloud of Frequent Terms in Health IS Research

Step 2. Generating TF-IDF Matrix

LSA analyzes the relationships between a set of documents and terms contained in these documents by generating a set of concepts that are related to both the documents and the terms. LSA starts with a term-document matrix which describes the occurrence of terms in corresponding documents. In this study, a TF-IDF (term frequency-inverse document frequency) term-document matrix with 2,386 rows (terms) and 571 columns (documents) was created, which represented the relevant importance of terms to a corpus of documents (Wu et al., 2008).

Step 3. Applying SVD on the TF-IDF Matrix

Central to LSA is singular value decomposition (SVD), which reduces the dimensionality of the term-document matrix to derive a particular latent semantic structure model. The latent semantic structure model is comprised of a set of orthogonal factors from which the original matrix can be approximated by linear combination (Deerwester et al., 1990). The SVD was applied to the TF-IDF matrix to reduce dimensionality. Given a TF-IDF matrix X with t terms (rows) and d documents (columns), the SVD of X can be represented as:

$$X = T\Sigma D^T$$

where T represents term eigenvectors, D denotes document eigenvectors, Σ is a diagonal matrix of the singular values in descending orders, and the subscript ^{T} denotes transpose operation. By retaining f significant factors, the matrix X can be approximated as:

$$\hat{X} = T_f \Sigma_f D_f^T$$

where $T_f\Sigma_f$ is a $t \times f$ term-by-factor matrix describing the term loadings to latent factors, and $D_f\Sigma_f$ is a $d \times f$ document-by-factor matrix showing the document loadings to latent factors.

Step 4. Factor Rotations and Interpretation

After dimension reduction, a factor analysis is typically applied for interpretive purposes. In this research, an orthogonal rotation method, Varimax, was applied to rotate the term-factor loading matrix and document-factor loading matrix to give more interpretable factor loadings on the solution. Then, we checked the high-loading terms and articles associated with each thematic factor and tried to label the factor as a meaningful and important Health IS research theme. Selecting the optimal number of latent factors f is an open issue and usually solved empirically (Kulkarni et al., 2014). We explored multiple solutions with 2 to 40 research themes and checked whether the theme labels make sense in each solution. Finally, a 22-factor solution appears most appropriate to capture the most meaningful and significant factors of Health IS research themes. The 22 themes identified and their high-loading terms are explained in Appendix C. The representative articles of each theme are described in Appendix D.

Appendix C: 22 Factors of Health IS Research

Table C1. Top Loading Terms for Health IS Factors (Themes)

Factor	Label	Top 30 terms
F1	Health IS Implementation	project, implement, process, system, develop, ehr, inform, telecar, organiz, actor, chang, structur, align, research, design, manag, redesign, organ, institut, strategi, practic, organis, collabor, theori, technologi, team, strateg, integr, busi, bpr
F2	Health IS Acceptance	model, accept, dss, physician, user, perceiv, technologi, usag, decis, resist, intent, support, individu, us, gp, factor, behavior, test, mobil, profession, studi, tam, result, context, influenc, adopt, busi, research, organiz, propos
F3	Health IS-Induced Anxiety and Resistance	anxieti, usag, german, intent, intellig, implement, basi, cultur, problem-focus, technology-rel, offer, surgic, initi, work-rel, pre-implement, nation, surveil, perceiv, expand, diminish, australian, threat, hospit, induc, profession, categori, contain, deeper, adopt, diffus
F4	Health IS Productivity	capit, labor, product, classifi, invest, social, ohc, medic, hospit, input, firm, doctor, impact, categori, effici, posit, data, evid, compon, profession, industri, sampl, longitudin, set, alloc, return, result, technologi, fuzzi, organiz
F5	Health IS Outsourcing, Performance, and Investment	outsourc, hospit, perform, cost, manag, invest, financi, servic, patient, firm, busi, system, decis, inform, network, impact, oper, valu, telecommun, effect, organ, level, adopt, resourc, increas, process, associ, integr, schedul, improv
F6	Health IS Innovation	innov, path, adopt, mobil, organ, telehealth, diffus, technologi, network, analysi, process, champion, institut, studi, research, context, organiz, actor, theori, practic, infrastructur, deviat, social, vision, framework, activ, public, contradict, understand, constitut
F7	National Health IS Programs	nh, servic, inform, nation, li, programm, manag, uk, project, system, chang, reform, data, technologi, govern, nurs, skill, comput, recruit, npfit, past, resourc, organ, develop, corpor, local, analys, research, exercis, billion
F8	Security of Health IS	secur, complianc, breach, invest, comput, protect, busi, model, inform, organ, polici, hie, operation, collabor, proactiv, matur, mobil, represent, consid, data, perceiv, perspect, regulatori, session, behavior, hipaa, legisl, control, actual, motiv
F9	Health Information Interchange	edi, usag, china, promot, organis, interchang, data, hospit, strategi, organ, electron, scottish, statu, servic, extent, describ, depth, volum, introduct, studi, chines, govern, stage, exchang, realiz, cultur, provid, divers, analyz, econom
F10	Health IS Compliance	complianc, secur, operation, clinic, hospit, pathwai, motiv, monitor, nurs, actual, effect, organiz, matur, breach, influenc, substitut, protect, physician, individu, affect, employe, manag, inform, perceiv, user, result, organ, found, investig, perform
F11	Trust of Health IS	trust, infomediari, project, relationship, belief, interperson, implement, dynam, system, inform, perceiv, studi, onlin, stakehold, gidden, qualiti, perform, factor, role, breakdown, relat, web, evolv, collabor, success, plai, type, integr, posit, outcom
F12	Health IS and Patient-Centered Care	pcc, expect, peopl, dimens, inform, locu, individu, empower, patient-cent, system, polici, self-efficaci, patient-centr, constitut, outsourc, unclear, anteced, phi, intern, collabor, affect, meet, draw, outcom, pathwai, survei, studi, qualiti, effici, technologi
F13	EMR and EHR	emr, physician, ehr, adopt, record, electron, hospit, assimil, system, practic, patient, learn, medic, implement, ident, intent, factor, profession, organiz, product, clinic, influenc, continu, inform, exchang, knowledg, technologi, studi, develop, theori

Table C1. Top Loading Terms for Health IS Factors (Themes)

F14	Mobile Health	mobil, patient, system, monitor, notif, clinic, devic, inform, decis, profession, support, medic, pathwai, nurs, comput, design, network, develop, collabor, rule, cdss, outsourc, hospit, algorithm, fuzzi, agent, doctor, emerg, provid, evalu
F15	Health Analytics and Data Mining	data, train, dea, subset, ann, predict, monoton, patient, network, model, perform, classif, neural, screen, mine, effici, cost, techniqu, ineffici, decis, forecast, blood, us, medic, cancer, featur, pattern, learn, method, threshold
F16	Health Information Search and Retrieval	search, session, engin, inform, queri, user, languag, web, portal, onlin, modul, non-english, qualiti, tool, rate, chines, issu, usag, approach, system, develop, hip, term, medic, topic, english, internet, us, sampl, data
F17	Health Image Retrieval and Management	imag, retriev, pain, neonat, algorithm, evalu, system, featur, radiologist, rank, learn, structur, approach, medic, regist, function, diagnos, method, fuzzi, match, read, content-bas, select, svm, develop, transform, global, perform, local, techniqu
F18	Clinical Pathway and Treatment Management	pathwai, clinic, model, treatment, process, medic, busi, patient, optim, qualiti, decis, deviat, integr, knowledg, improv, support, readmiss, propos, trial, method, approach, complianc, predict, cdss, knowledge-bas, hospit, path, redesign, error, digit
F19	Knowledge Management in Healthcare	knowledg, share, collabor, manag, ohc, commun, transfer, support, social, medic, process, network, pathwai, nurs, inform, clinic, develop, decis, integr, activ, suppli, project, system, specif, chain, outsourc, profession, parti, virtual, barrier
F20	RFID and Tracking in Healthcare	rfid, tag, adopt, reader, locat, frequenc, identif, radio, technologi, hospit, system, framework, scenario, studi, industri, track, optim, environ, benefit, pervas, inform, organ, nomad, placement, decis, propos, patient, algorithm, develop, consid
F21	Health Consumer Privacy	privaci, phi, inform, concern, individu, complianc, person, phr, commun, data, regul, medic, polici, research, vhc, share, emr, disclosur, provid, perceiv, record, system, patient, risk, collabor, hi, protect, exchang, insur, control
F22	Online Health Communities and Digital Services	onlin, commun, social, patient, servic, qualiti, valu, perceiv, digit, inform, satisfact, provid, consum, network, phi, physician, behavior, research, benefit, media, particip, model, motiv, technologi, monitor, effect, share, mechan, peopl, person

Appendix D: Representative Articles of 22 Health IS Research Themes

Table D1. Representative Articles of Health IS Research Themes

Theme	Representative paper	Journal	Loading
F1. Health IS Implementation	Boonstra & van Offenbeek, 2010	*Information Systems Journal*	0.083
	Soh & Sia, 2004	*Journal of Strategic Information Systems*	0.062
	Mitchell & Zmud, 1999	*Organization Science*	0.062
	Kim & Kim, 1997	*Information & Management*	0.057
	Aanestad & Jensen, 2016	*Information and Organization*	0.056
	Iacovou, 1999	*Journal of Information Technology*	0.054
	Vieru & Rivard, 2014	*International Journal of Information Management*	0.052
	Palvia et al., 2015	*Communications of the Association for Information Systems*	0.050
	Huerta et al., 2013	*Decision Support Systems*	0.047
	Xiao et al., 2014	*Information Systems Management*	0.047
	Madon et al., 2007	*Information Society*	0.047
	Strong et al., 2014	*Journal of the Association for Information Systems*	0.044
	Findikoglu & Watson-Manheim, 2016	*Journal of Information Technology*	0.044
	Davidson & Chiasson, 2005	*European Journal of Information Systems*	0.043
	Chandwani & De, 2017	*Information Systems Frontiers*	0.043
	Kohli & Tan, 2016	*MIS Quarterly*	0.042
	Jensen et al., 2009	*Journal of Information Technology*	0.040
	Lapointe & Rivard, 2007	*Organization Science*	0.039
	Guah, 2008	*International Journal of Information Management*	0.039
	Abraham & Junglas, 2011	*Journal of Strategic Information Systems*	0.039
	Jayasuriya, 1999	*International Journal of Information Management*	0.038
	Cho et al., 2008	*European Journal of Information Systems*	0.038
	Rose & Schlichter, 2013	*Information Systems Journal*	0.038
	Aanestad & Jensen, 2011	*Journal of Strategic Information Systems*	0.037
	Yetton et al., 1999	*Journal of Information Technology*	0.036
	Duclos, 2016	*Journal of Information Technology*	0.036
	Mengiste & Aanestad, 2013	*Information and Organization*	0.036
	Hussain & Cornelius, 2009	*Information Systems Journal*	0.036
	Lapointe & Rivard, 2005	*MIS Quarterly*	0.035
	Ben Ayed et al., 2010	*Decision Support Systems*	0.034
	Lam & Ching, 1998	*Information Systems Management*	0.034
	Mekonnen & Sahay, 2008	*European Journal of Information Systems*	0.034
	Currie, 2012	*Journal of Information Technology*	0.034
	Braa et al., 2007	*MIS Quarterly*	0.034
	Boonstra et al., 2008	*European Journal of Information Systems*	0.034
	Braa et al., 2004	*MIS Quarterly*	0.034

Table D1. Representative Articles of Health IS Research Themes

	Silva & Hirschheim, 2007	*MIS Quarterly*	0.033
	Connell & Young, 2007	*Information & Management*	0.033
	Love & Cooper, 1996	*International Journal of Information Management*	0.032
	van Offenbeek et al., 2013	*European Journal of Information Systems*	0.032
	Mouttham et al., 2012	*Information Systems Frontiers*	0.032
	Puri et al., 2009	*Information and Organization*	0.031
	Rivard et al., 2011	*Journal of the Association for Information Systems*	0.031
	Schlichter & Rose, 2013	*European Journal of Information Systems*	0.031
	Foshay & Kuziemsky, 2014	*International Journal of Information Management*	0.031
	Aydin & Rice, 1991	*Information & Management*	0.030
	Brooks et al., 2015	*International Journal of Information Management*	0.030

F2. Health IS Acceptance	Shibl et al., 2013	*Decision Support Systems*	0.092
	Yi et al., 2006	*Information & Management*	0.090
	Bhattacherjee & Hikmet, 2007	*European Journal of Information Systems*	0.083
	Chau & Hu, 2002	*Information & Management*	0.078
	Devolder et al., 2012	*Information & Management*	0.069
	Moores, 2012	*Decision Support Systems*	0.064
	Walter & Lopez, 2008	*Decision Support Systems*	0.064
	Hu et al., 1999	*Journal of Management Information Systems*	0.064
	Bhattacherjee & Hikmet, 2008	*Journal of Computer Information Systems*	0.063
	Chau & Hu, 2002	*Journal of Management Information Systems*	0.062
	Park et al., 2016	*Information Technology & People*	0.059
	van Offenbeek et al., 2013	*European Journal of Information Systems*	0.059
	Ayanso et al., 2015	*Decision Support Systems*	0.056
	Liang et al., 2010	*Journal of the Association for Information Systems*	0.054
	Barki et al., 2008	*Journal of Information Technology*	0.050
	Deng et al., 2015	*Information Technology & People*	0.050
	Lapointe & Rivard, 2005	*MIS Quarterly*	0.047
	Gagnon et al., 2016	*International Journal of Information Management*	0.046
	Mou et al., 2016	*Information Technology & People*	0.045
	Johnson et al., 2014	*Decision Support Systems*	0.045
	Ng et al., 2009	*Decision Support Systems*	0.044
	Baird & Raghu, 2015	*European Journal of Information Systems*	0.042
	Wu et al., 2011	*Decision Support Systems*	0.041
	Scheepers et al., 2006	*European Journal of Information Systems*	0.041
	Liu & Ma, 2005	*Information & Management*	0.041
	Lapointe & Rivard, 2007	*Organization Science*	0.036
	Cocosila & Archer, 2016	*Communications of the Association for Information Systems*	0.034

Table D1. Representative Articles of Health IS Research Themes

	Song & Zahedi, 2007	*Decision Support Systems*	0.034
	Melas et al., 2014	*European Journal of Information Systems*	0.034
	Lu & Gustafson, 1994	*International Journal of Information Management*	0.033
	Hung et al., 2014	*Decision Support Systems*	0.030
F3. Health IS-Induced Anxiety and Resistance	Kummer et al., 2017	*Information & Management*	0.285
	Bick et al., 2015	*Information Systems Management*	0.255
F4. Health IS Productivity	Menon et al., 2000	*Information Systems Research*	0.267
	Lee & Menon, 2000	*Journal of Management Information Systems*	0.130
	Guo et al., 2017	*Journal of Management Information Systems*	0.129
	Ko & Osei-Bryson, 2004	*Information Systems Journal*	0.067
	Menon & Lee, 2000	*Decision Support Systems*	0.064
	Baker et al., 2017	*Journal of Strategic Information Systems*	0.044
	Menon et al., 2009	*Journal of Management Information Systems*	0.041
H5. Health IS Outsourcing, Performance, and Investment	Thouin et al., 2009	*Information & Management*	0.162
	Lorence & Spink, 2004	*International Journal of Information Management*	0.149
	Setia et al., 2011	*Journal of the Association for Information Systems*	0.069
	Kohli et al., 2012	*MIS Quarterly*	0.068
	Lin et al., 2014	*Information & Management*	0.051
	Walczak & Scharf, 2000	*Decision Support Systems*	0.050
	Bhattacherjee et al., 2007	*Information Systems Management*	0.049
	Abrahams & Ragsdale, 2012	*Decision Support Systems*	0.047
	Du, 2015	*Information Systems Research*	0.047
	Salge et al., 2015	*MIS Quarterly*	0.045
	Lorence, 2008	*Journal of Computer Information Systems*	0.045
	Wu & Hu, 2012	*Journal of the Association for Information Systems*	0.043
	Wu et al., 2016	*International Journal of Information Management*	0.042
	Ko & Osei-Bryson, 2004	*Information Systems Journal*	0.042
	Bradley et al., 2012	*Journal of Information Technology*	0.041
	Menon & Lee, 2000	*Decision Support Systems*	0.040
	Baird & Raghu, 2015	*European Journal of Information Systems*	0.040
	Cordier & Riane, 2013	*Decision Support Systems*	0.039
	Lee & Menon, 2000	*Journal of Management Information Systems*	0.039
	Menon & Kohli, 2013	*Information Systems Research*	0.036
	Tarakci et al., 2009	*Decision Support Systems*	0.036

Table D1. Representative Articles of Health IS Research Themes

	Hung et al., 2010	*Decision Support Systems*	0.036
	Qu et al., 2012	*Decision Support Systems*	0.035
	Kohli et al., 2001	*Decision Support Systems*	0.035
	Menon et al., 2009	*Journal of Management Information Systems*	0.035
	Leidner et al., 2010	*Journal of Strategic Information Systems*	0.035
	Bardhan & Thouin, 2013	*Decision Support Systems*	0.034
	Spaulding et al., 2013	*Decision Support Systems*	0.034
	Baker et al., 2017	*Journal of Strategic Information Systems*	0.034
	Kwon & Johnson, 2014	*MIS Quarterly*	0.033
	Devaraj & Kohli, 2003	*Management Science*	0.033
	Forgionne & Kohli, 1996	*Decision Support Systems*	0.033
	Kohli & Devaraj, 2004	*Decision Support Systems*	0.032
	Liang et al., 2017	*Information & Management*	0.032
	Devaraj & Kohli, 2000	*Journal of Management Information Systems*	0.032
	Manfreda et al., 2014	*Journal of Computer Information Systems*	0.031
	Klein, 2012	*Information & Management*	0.031
	Wu et al., 2016	*Information & Management*	0.030
	Yeow & Goh, 2015	*MIS Quarterly*	0.030
	Fairbank et al., 2006	*Journal of Management Information Systems*	0.030
	Xue et al., 2008	*MIS Quarterly*	0.030

F6. Health IS Innovation	Singh et al., 2015	*MIS Quarterly*	0.135
	Cho et al., 2007	*Journal of Information Technology*	0.100
	Bunduchi et al., 2015	*Information & Management*	0.085
	Davidson et al., 2015	*Information and Organization*	0.083
	Cho & Mathiassen, 2007	*European Journal of Information Systems*	0.077
	Fedorowicz & Gogan, 2010	*Information Systems Frontiers*	0.067
	van Laere & Aggestam, 2016	*European Journal of Information Systems*	0.066
	Currie & Seddon, 2014	*Information Systems Management*	0.065
	Bernardi et al., 2017	*Journal of the Association for Information Systems*	0.062
	Kaganer et al., 2010	*Journal of the Association for Information Systems*	0.060
	Leidner et al., 2010	*Journal of Strategic Information Systems*	0.059
	Sanner et al., 2014	*Journal of the Association for Information Systems*	0.056
	Tarafdar & Gordon, 2007	*Journal of Strategic Information Systems*	0.054
	Cho et al., 2009	*Information Technology & People*	0.052
	Baird et al., 2012	*Journal of Management Information Systems*	0.043
	Yetton et al., 1999	*Journal of Information Technology*	0.042
	Wainwright & Waring, 2007	*Journal of Information Technology*	0.041
	Igira, 2008	*Journal of Information Technology*	0.039

Table D1. Representative Articles of Health IS Research Themes

	Kimble et al., 2010	*International Journal of Information Management*	0.037
	Angst et al., 2010	*Management Science*	0.034
	Grisot et al., 2014	*Journal of the Association for Information Systems*	0.034
	Manda & Herstad, 2015	*Information Technology & People*	0.031

F7. National Health IS Programs	Brittain, 1992	*International Journal of Information Management*	0.172
	Beynondavies, 1994	*International Journal of Information Management*	0.103
	Brennan, 2007	*Journal of Information Technology*	0.095
	Currie & Guah, 2006	*Information Systems Management*	0.089
	Fernando et al., 2012	*Information Systems Frontiers*	0.084
	Brittain & Macdougall, 1995	*International Journal of Information Management*	0.080
	Clegg & Shepherd, 2007	*Journal of Information Technology*	0.077
	Gillies, 1998	*Journal of Information Technology*	0.071
	Currie & Guah, 2007	*Journal of Information Technology*	0.066
	Love & Cooper, 1996	*International Journal of Information Management*	0.065
	McGrath, 2002	*European Journal of Information Systems*	0.056
	Guah, 2008	*International Journal of Information Management*	0.055
	Hanlon et al., 2005	*Human Relations*	0.053
	Forte, 1994	*European Journal of Information Systems*	0.052
	Gillies, 1995	*Journal of Information Technology*	0.051
	Checkland & Holwell, 1993	*Information Systems Journal*	0.045
	Eason, 2007	*Journal of Information Technology*	0.040
	Mark, 2007	*Journal of Information Technology*	0.036
	Farmer et al., 1999	*International Journal of Information Management*	0.035
	Wiredu & Sorensen, 2006	*European Journal of Information Systems*	0.034
	Buchanan & McMenemy, 2012	*International Journal of Information Management*	0.030

Table D1. Representative Articles of Health IS Research Themes

F8. Security of Health IS	Kwon & Johnson, 2013	*Journal of Management Information Systems*	0.187
	Ng et al., 2009	*Decision Support Systems*	0.156
	Kwon & Johnson, 2014	*MIS Quarterly*	0.145
	Vaast, 2007	*Journal of Strategic Information Systems*	0.137
	Huang et al., 2014	*Decision Support Systems*	0.114
	Stahl et al., 2012	*Information Systems Journal*	0.099
	Thomas & Botha, 2007	*Information Systems Management*	0.097
	Rodriguez et al., 2011	*Decision Support Systems*	0.095
	Hedstrom et al., 2011	*Journal of Strategic Information Systems*	0.090
	Angst et al., 2017	*MIS Quarterly*	0.081
	Yang & Lee, 2016	*Information Systems Frontiers*	0.074
	Fernandez-Medina et al., 2006	*Decision Support Systems*	0.064
	Pussewalage & Oleshchuk, 2016	*International Journal of Information Management*	0.060
	Wang et al., 2012	*Decision Support Systems*	0.059
	Bansal & Zahedi, 2014	*Journal of Computer Information Systems*	0.051
	Cousins, 2016	*Communications of the Association for Information Systems*	0.051
	Bai et al., 2014	*Decision Support Systems*	0.048
	He et al., 2012	*Information Systems Frontiers*	0.039
	Garfinkel et al., 2007	*Information Systems Research*	0.033
F9. Health Information Interchange	Liang et al., 2004	*International Journal of Information Management*	0.294
	Spinardi et al., 1997	*Journal of Strategic Information Systems*	0.181
F10. Health IS Compliance	Kwon & Johnson, 2013	*Journal of Management Information Systems*	0.164
	Staats et al., 2017	*Management Science*	0.120
	Heart et al., 2011	*Journal of the Association for Information Systems*	0.106
	Warkentin et al., 2011	*European Journal of Information Systems*	0.094
	Foth, 2016	*European Journal of Information Systems*	0.060
	Hedstrom et al., 2011	*Journal of Strategic Information Systems*	0.057
	Parks et al., 2017	*European Journal of Information Systems*	0.054
	Kostagiolas et al., 2014	*International Journal of Information Management*	0.044

Table D1. Representative Articles of Health IS Research Themes

F11. Trust of Health IS	Schlichter & Rose, 2013	*European Journal of Information Systems*	0.174
	Zahedi & Song, 2008	*Journal of Management Information Systems*	0.168
	Song & Zahedi, 2007	*Decision Support Systems*	0.159
	Paul & McDaniel, 2004	*MIS Quarterly*	0.154
	Rose & Schlichter, 2013	*Information Systems Journal*	0.153
	Leimeister et al., 2005	*Journal of Management Information Systems*	0.081
	Kostagiolas et al., 2014	*International Journal of Information Management*	0.063
	Yi et al., 2013	*Decision Support Systems*	0.061
	Eason, 2007	*Journal of Information Technology*	0.059
	Bansal et al., 2010	*Decision Support Systems*	0.052
	Deng et al., 2015	*Information Technology & People*	0.048
	Li et al., 2014	*Decision Support Systems*	0.033
	Mou et al., 2016	*Information Technology & People*	0.030
F12. Health IS and Patient Centered-Care	Zhou et al., 2017	*Information & Management*	0.296
	Klecun, 2016	*European Journal of Information Systems*	0.088
F13. EMR and EHR	Cocosila & Archer, 2016	*Communications of the Association for Information Systems*	0.116
	Reardon & Davidson, 2007	*European Journal of Information Systems*	0.113
	Goo et al., 2015	*Information & Management*	0.102
	Miller & Tucker, 2009	*Management Science*	0.101
	Mishra et al., 2012	*Information Systems Research*	0.099
	Ayanso et al., 2015	*Decision Support Systems*	0.098
	Gagnon et al., 2016	*International Journal of Information Management*	0.086
	Davidson & Heslinga, 2007	*Information Systems Management*	0.086
	Bhargava & Mishra, 2014	*Management Science*	0.084
	Huerta et al., 2013	*Decision Support Systems*	0.080
	Roberts et al., 2016	*Information & Management*	0.063
	Kohli & Tan, 2016	*MIS Quarterly*	0.056
	Ben-Zion et al., 2014	*Information Systems Management*	0.055
	Chang et al., 2009	*Information & Management*	0.052
	Palvia et al., 2015	*Communications of the Association for Information Systems*	0.051
	Shaw, 2014	*International Journal of Information Management*	0.051
	Sherer et al., 2016	*Information & Management*	0.049
	Walter & Lopez, 2008	*Decision Support Systems*	0.047
	Ozdemir et al., 2011	*Information Systems Research*	0.047

Table D1. Representative Articles of Health IS Research Themes

	Williams & Boren, 2008	*International Journal of Information Management*	0.039
	Angst & Agarwal, 2009	*MIS Quarterly*	0.037
	Jensen & Aanestad, 2007	*Information Systems Management*	0.036
	Findikoglu & Watson-Manheim, 2016	*Journal of Information Technology*	0.033
	Jensen & Aanestad, 2007	*European Journal of Information Systems*	0.030

F14. Mobile Health	Lussier et al., 2007	*Decision Support Systems*	0.106
	Sneha & Varshney, 2013	*Decision Support Systems*	0.080
	Thomas & Botha, 2007	*Information Systems Management*	0.070
	Varshney, 2008	*Decision Support Systems*	0.067
	Varshney, 2014	*Decision Support Systems*	0.064
	Corchado et al., 2008	*Decision Support Systems*	0.059
	Chatterjee et al., 2009	*Decision Support Systems*	0.059
	Michalowski et al., 2003	*Decision Support Systems*	0.053
	Varshney, 2014	*Decision Support Systems*	0.053
	Barjis et al., 2013	*Decision Support Systems*	0.041
	Sneha & Varshney, 2009	*Decision Support Systems*	0.040
	Scheepers et al., 2006	*European Journal of Information Systems*	0.039
	Wu et al., 2011	*Decision Support Systems*	0.039
	Manda & Herstad, 2015	*Information Technology & People*	0.035
	Mouttham et al., 2012	*Information Systems Frontiers*	0.032
	Wiredu & Sorensen, 2006	*European Journal of Information Systems*	0.031

F15. Health Analytics and Data Mining	Pendharkar & Rodger, 2003	*Decision Support Systems*	0.220
	Pendharkar et al., 2000	*Journal of Computer Information Systems*	0.124
	Walczak & Scharf, 2000	*Decision Support Systems*	0.088
	Zhang et al., 2009	*Decision Support Systems*	0.077
	Zhang et al., 2009	*Information Systems Frontiers*	0.059
	Lee & Park, 2001	*Information & Management*	0.056
	Zhou et al., 2016	*Decision Support Systems*	0.055
	Pendharkar, 2005	*Decision Support Systems*	0.051
	Churilov et al., 2005	*Journal of Management Information Systems*	0.051
	Klenk et al., 2009	*Information Systems Frontiers*	0.050
	Yang et al., 2010	*Decision Support Systems*	0.042
	Zolbanin et al., 2015	*Decision Support Systems*	0.042
	Cao et al., 2012	*Decision Support Systems*	0.041
	Tolle et al., 2000	*Decision Support Systems*	0.041
	Chen et al., 2016	*Decision Support Systems*	0.041

Table D1. Representative Articles of Health IS Research Themes

	Walczak et al., 2003	*Decision Support Systems*	0.040
	Dag et al., 2017	*Decision Support Systems*	0.039
	Gao et al., 2017	*Decision Support Systems*	0.039
	Lan et al., 2010	*Decision Support Systems*	0.039
	Mangiameli et al., 2004	*Decision Support Systems*	0.038
	Lee et al., 2009	*Information Systems Frontiers*	0.037
	Delen et al., 2012	*Decision Support Systems*	0.036
	Yeh et al., 2011	*Decision Support Systems*	0.034
	Ghandforoush & Sen, 2010	*Decision Support Systems*	0.034
	Poston et al., 2007	*Information Systems Management*	0.034
	Dag et al., 2016	*Decision Support Systems*	0.033
	Oztekin et al., 2011	*Decision Support Systems*	0.033
	Bertsimas et al., 2016	*Management Science*	0.032
	Abrahams & Ragsdale, 2012	*Decision Support Systems*	0.032
	Sakellaropoulos & Nikiforidis, 2000	*Decision Support Systems*	0.031
	da Silva et al., 2011	*Decision Support Systems*	0.031
	Bardhan et al., 2015	*Information Systems Research*	0.031

F16. Health Information Search and Retrieval	Wang et al., 2012	*Decision Support Systems*	0.199
	Chau et al., 2008	*Decision Support Systems*	0.172
	Chung et al., 2006	*Decision Support Systems*	0.118
	Kitchens et al., 2014	*Decision Support Systems*	0.107
	Zhou et al., 2006	*Decision Support Systems*	0.104
	Xiao et al., 2014	*Decision Support Systems*	0.092
	Nguyen et al., 2015	*Information Systems Frontiers*	0.080
	Nguyen et al., 2015	*Communications of the Association for Information Systems*	0.061
	Morgan & Trauth, 2013	*Information Technology & People*	0.059
	Houston et al., 2000	*Decision Support Systems*	0.055
	Lu et al., 2008	*Decision Support Systems*	0.044

Table D1. Representative Articles of Health IS Research Themes

F17. Health Image Retrieval and Management	Tang & Ip, 2009	*Information Systems Frontiers*	0.161
	da Silva et al., 2011	*Decision Support Systems*	0.146
	Sheng et al., 2000	*Decision Support Systems*	0.119
	Brahnam et al., 2007	*Decision Support Systems*	0.115
	Hu et al., 2006	*Decision Support Systems*	0.103
	Blum & Aboulafia, 2003	*Information Systems Frontiers*	0.084
	Wong et al., 2009	*Information Systems Frontiers*	0.074
	Hachaj, 2014	*International Journal of Information Management*	0.056
	Bourouis et al., 2014	*Decision Support Systems*	0.041
	Law et al., 1995	*Information & Management*	0.036
	Purao & Han, 2000	*Journal of Management Information Systems*	0.033
F18. Clinical Pathway and Treatment Management	Yang et al., 2012	*Information Systems Frontiers*	0.157
	Yao & Kumar, 2013	*Decision Support Systems*	0.104
	Li et al., 2014	*European Journal of Information Systems*	0.086
	Bertsimas et al., 2016	*Management Science*	0.062
	Adeyemi et al., 2013	*Decision Support Systems*	0.058
	Churilov et al., 2005	*Journal of Management Information Systems*	0.040
	Bielza et al., 2008	*Decision Support Systems*	0.036
	van Valkenhoef et al., 2013	*Decision Support Systems*	0.035
	Akcura & Ozdemir, 2014	*Decision Support Systems*	0.033
F19. Knowledge Management in Healthcare	Al-Karaghouli et al., 2013	*Information Systems Management*	0.116
	Yan et al., 2016	*Information & Management*	0.115
	Mohan et al., 2007	*Decision Support Systems*	0.109
	Pedersen & Larsen, 2001	*Decision Support Systems*	0.108
	Lin et al., 2008	*Information & Management*	0.104
	Rubenstein-Montano et al., 2000	*Journal of Computer Information Systems*	0.088
	Paul, 2006	*Journal of Management Information Systems*	0.084
	Ghosh & Scott, 2007	*Information Systems Management*	0.081
	Lim et al., 2015	*Journal of Management Information Systems*	0.068
	Yang et al., 2012	*Information Systems Frontiers*	0.065
	Bergquist et al., 2001	*Journal of Information Technology*	0.061
	Gagnon et al., 2015	*International Journal of Information Management*	0.058
	Kimble et al., 2010	*International Journal of Information Management*	0.054
	Chen, 1994	*Decision Support Systems*	0.050
	Ong et al., 2005	*Decision Support Systems*	0.047
	Wu & Hu, 2012	*Journal of the Association for Information Systems*	0.045
	Sheng et al., 2000	*Decision Support Systems*	0.045

Table D1. Representative Articles of Health IS Research Themes

	Shibl et al., 2013	*Decision Support Systems*	0.045
	Haghighi et al., 2013	*Decision Support Systems*	0.043
	Li et al., 2014	*European Journal of Information Systems*	0.043
	Mitchell, 2006	*MIS Quarterly*	0.043
	Zhuang et al., 2013	*Decision Support Systems*	0.041
	Leidner, 2010	*Journal of Strategic Information Systems*	0.037
	Peng et al., 2014	*Journal of Management Information Systems*	0.036
	Kamsu-Foguem et al., 2012	*Decision Support Systems*	0.034
	Ben Ayed et al., 2010	*Decision Support Systems*	0.034
	Kallinikos & Tempini, 2014	*Information Systems Research*	0.034
	Pla et al., 2013	*Decision Support Systems*	0.031

F20. RFID and Tracking in Healthcare	Tu et al., 2009	*Decision Support Systems*	0.156
	Cao et al., 2014	*Information & Management*	0.142
	Yazici, 2014	*International Journal of Information Management*	0.134
	Oztekin et al., 2010	*Decision Support Systems*	0.121
	Lee & Shim, 2007	*European Journal of Information Systems*	0.119
	Lu et al., 2013	*Decision Support Systems*	0.114
	Zhou et al., 2012	*Decision Support Systems*	0.101
	Wamba et al., 2013	*International Journal of Information Management*	0.075
	Chan et al., 2012	*Decision Support Systems*	0.074
	Meiller et al., 2011	*Decision Support Systems*	0.061
	Ngai et al., 2009	*Information Systems Frontiers*	0.053
	Pietrabissa et al., 2013	*Decision Support Systems*	0.042

F21. Health Consumer Privacy	Xu et al., 2011	*Journal of the Association for Information Systems*	0.154
	Parks et al., 2017	*European Journal of Information Systems*	0.121
	Kordzadeh et al., 2016	*International Journal of Information Management*	0.114
	Adjerid et al., 2016	*Management Science*	0.096
	Li et al., 2014	*Decision Support Systems*	0.093
	Miller & Tucker, 2009	*Management Science*	0.086
	Siau & Kam, 2006	*Journal of Information Technology*	0.085
	Kordzadeh & Warren, 2017	*Journal of the Association for Information Systems*	0.076
	Bansal & Zahedi, 2014	*Journal of Computer Information Systems*	0.072
	Angst & Agarwal, 2009	*MIS Quarterly*	0.064
	Bansal et al., 2010	*Decision Support Systems*	0.061
	Warkentin et al., 2011	*European Journal of Information Systems*	0.060
	Li & Qin, 2017	*Information Systems Research*	0.060
	Weber-Jahnke & Obry, 2012	*Information Systems Frontiers*	0.057

Table D1. Representative Articles of Health IS Research Themes

	Thatcher & Clemons, 2000	*Journal of Management Information Systems*	0.055
	Wimmer et al., 2016	*Decision Support Systems*	0.055
	Anderson & Agarwal, 2011	*Information Systems Research*	0.050
	Pussewalage & Oleshchuk, 2016	*International Journal of Information Management*	0.048
	Dillon & Lending, 2010	*Journal of Computer Information Systems*	0.039
	He et al., 2012	*Information Systems Frontiers*	0.036
	Thomas & Botha, 2007	*Information Systems Management*	0.034
	Garfinkel et al., 2007	*Information Systems Research*	0.032
	Airoldi et al., 2011	*Decision Support Systems*	0.030

F22. Online Health Communities and Digital Services	Hajli, 2014	*International Journal of Information Management*	0.100
	Chiu et al., 2015	*International Journal of Information Management*	0.099
	Yang et al., 2015	*Decision Support Systems*	0.086
	Gao et al., 2015	*MIS Quarterly*	0.085
	Johnston et al., 2013	*Information Technology & People*	0.074
	Ba & Wang, 2013	*Decision Support Systems*	0.072
	Kordzadeh et al., 2016	*International Journal of Information Management*	0.068
	Goh et al., 2016	*MIS Quarterly*	0.067
	Baird & Raghu, 2015	*European Journal of Information Systems*	0.065
	Xiao et al., 2014	*Decision Support Systems*	0.061
	Yan & Tan, 2014	*Information Systems Research*	0.060
	Liang et al., 2017	*Journal of the Association for Information Systems*	0.060
	Yan et al., 2015	*Information Systems Research*	0.059
	Yan & Tan, 2017	*Journal of Management Information Systems*	0.058
	Josefsson, 2005	*Information Society*	0.054
	Kordzadeh & Warren, 2017	*Journal of the Association for Information Systems*	0.051
	Guo et al., 2017	*Journal of Management Information Systems*	0.049
	Ridings & Wasko, 2010	*Journal of the Association for Information Systems*	0.048
	Yan et al., 2016	*Information & Management*	0.044
	Mou et al., 2016	*Information Technology & People*	0.042
	Kitchens et al., 2014	*Decision Support Systems*	0.039
	Klein, 2007	*European Journal of Information Systems*	0.037
	Barrett et al., 2016	*Information Systems Research*	0.034
	Miller & Tucker, 2013	*Information Systems Research*	0.034
	Ozdemir et al., 2011	*Information Systems Research*	0.030

Appendix E: Author Citation Matrix

To analyze the author-level citation relationship, we aggregated the article-level citation information to the author level based on the authors of articles and the raw article citation relationship extracted from the Health IS research data set, thereby providing a more accurate measure for citation analysis at a higher level than the document-level analysis. This information aggregation provides more flexible and valid measures than traditional methods, which rely on the first authors without the consideration of co-authorship (e.g., Culnan, 1986, 1987; Ding, Chowdhury, & Foo, 1999; Pilkington & Meredith, 2009). Table E1 shows a subset of the Health IS author citation matrix which is aggregated from the raw document-level citation relationships. We noticed that some author names have multiple initials. For example, "Anderson, C." and "Anderson, C. L." represent the same author, and "Hu, P. J. H." sometime displays as "Hu, P. J." For such case, we kept an identical scholar name if multiple initials represented the same scholar.

Table E1. Raw Health IS Author Citation Matrix (7 x 7 Subset)

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Agarwal, R.	6	5	7	0	8	6	6
2. Davidson, E.	0	4	1	0	3	3	3
3. Devaraj, S.	1	0	5	0	9	0	0
4. Hu, P. J.	0	1	0	4	2	0	0
5. Kohli, R.	4	2	7	0	14	2	2
6. Lapointe, L.	0	0	0	0	1	3	3
7. Rivard, S.	0	0	0	0	1	3	3

Appendix F: Summary of Author Productivity

As shown in Table F1, among all 1236 Health IS scholars identified, 1025 (82.0%) authors have published only one Health IS study and 131 (10.6%) researchers have two publications. The most prolific authors (with three or more publications) accounts for 6.5% of the author pool.

Table F1. Summary of Author Productivity

Number of articles	Number of authors	Percent	Cumulative percent
1	1025	82.9%	82.9%
2	131	10.6%	93.5%
3	42	3.4%	96.9%
4	16	1.3%	98.2%
5	12	1.0%	99.2%
6	2	0.2%	99.4%
7	1	0.1%	99.4%
8	2	0.2%	99.6%
9	4	0.3%	99.9%
10	1	0.1%	100.0%
Total	**1236**	**100%**	

Appendix G: Top Health IS Scholars by Research Theme

Table G1. Thought Leadership within Health IS Research Themes

Theme	Author	Citations
F1. Health IS Implementation	Lapointe, L.	50
	Rivard, S.	50
	Davidson, E.	41
	Chismar, W. G.	39
	Sahay, S.	31
	Monteiro, E.	28
	Aanestad, M.	25
	Hanseth, O.	22
F2. Health IS Acceptance	Lapointe, L.	44
	Rivard, S.	44
	Chau, P. Y. K.	42
	Hu, P. J.	42
	Devaraj, S.	34
	Kohli, R.	34
	Sheng, O. R. L.	22
	Tam, K. Y.	22
F3. Health IS-Induced Anxiety and Resistance	Bick, M.	1
	Kummer, T. F.	1
	Ryschka, S.	1
F4. Health IS Productivity	Menon, N. M.	39
	Lee, B.	31
	Eldenburg, L.	22
F5. Health IS Outsourcing, Performance, and Investment	Kohli, R.	79
	Devaraj, S.	65
	Menon, N. M.	20
F6. Health IS Innovation	Mathiassen, L.	18
	Agarwal, R.	17
	Angst, C.	17
	Kelley, K.	17
	Sambamurthy, V.	17
F7. National Health IS Programs	Currie, W. L.	22
	Guah, M. W.	22
F8. Security of Health IS	Kankanhalli, A.	3
	Ng, B. Y.	3
	Xu, Y. J.	3
F9. Health Information Interchange	Bhattacherjee, A.	15
	Hikmet, N.	15
F10. Health IS Compliance	Johnston, A. C.	2
	Shropshire, J.	2
	Warkentin, M.	2
F11. Trust of Health IS	Zahedi, F. M.	19
	Song, J.	17
	McDaniel, R. R.	12
	Paul, D. L.	12

Table G1. Thought Leadership within Health IS Research Themes

F12. Health IS and Patient-Centered Care	Klecun, E.	1
F13. EMR and EHR	Agarwal, R.	28
	Angst, C.	28
	Davidson, E.	18
	Aanestad, M.	16
	Jensen, T. B.	16
	Reardon, J. L.	13
F14. Mobile Health	Varshney, U.	16
	Sarker, S.	10
	Sneha, S.	8
F15. Health Analytics and Data Mining	Aron, R.	11
	Dutta, S.	11
	Janakiraman, R.	11
	Pathak, P. A.	11
	Delen, D.	8
F16. Health Information Search and Retrieval	Chen, H. C.	4
	Barrett, M.	3
	Kohli, R.	3
	Qin, J. L.	3
	Salge, T. O.	3
	Zhou, Y. L.	3
F17. Health Image Retrieval and Management	Hu, P. J.	4
	Sheng, O. R. L.	4
	Wei, C. P.	4
F18. Clinical Pathway and Treatment Management	Bardhan, I.	3
	Kirksey, K.	3
	Oh, J. H.	3
	Zheng, Z. Q.	3
F19. Knowledge Management in Healthcare	Paul, D. L.	8
	Chang, N.	3
	Hu, P. J.	3
	Kallinikos, J.	3
	Leidner, D. E.	3
	Sheng, O. R. L.	3
F20. RFID and Tracking in Healthcare	Piramuthu, S.	13
	Zhou, W.	13
	Tu, Y. J.	10
F21. Health Consumer Privacy	Agarwal, R.	34
	Angst, C.	24
	Anderson, C.	10
	Bansal, G.	9
	Gefen, D.	9
	Zahedi, F. M.	9
F22. Online Health Communities and Digital Services	Agarwal, R.	6
	Varshney, U.	6
	Klein, R.	5

Appendix H: Summary of Journals Cited by Health IS Research

Table H1 shows the summary of journals that have been cited at least 20 times by Health IS research in our data set.

Table H1. Journals Cited by Health IS Research

Journal	Journal abbr.	# cited by Health IS	Discipline
MIS Quarterly	MIS QUART	1579	Information systems
Information Systems Research	INFORM SYST RES	816	Information systems
Management Science	MANAGE SCI	553	Management
Decision Support Systems	DECIS SUPPORT SYST	516	Information systems
Journal of Management Information Systems	J MANAGE INFORM SYST	510	Information systems
Organization Science	ORGAN SCI	436	Management
Journal of the American Medical Informatics Association	J AM MED INFORM ASSN	433	Health informatics
International Journal of Medical Informatics	INT J MED INFORM	393	Health informatics
Communications of the ACM	COMMUN ACM	366	Computer science; information systems
European Journal of Information Systems	EUR J INFORM SYST	366	Information systems
Academy of Management Review	ACAD MANAGE REV	316	Management
Information & Management	INFORM MANAGE	313	Information systems
Administrative Science Quarterly	ADMIN SCI QUART	282	Management
Health Affairs	HEALTH AFFAIR	279	Health service
JAMA-Journal of the American Medical Association	JAMA-J AM MED ASSOC	233	Medicine
Academy of Management Journal	ACAD MANAGE J	229	Management
Journal of the Association for Information Systems	J ASSOC INF SYST	199	Information systems
Journal of Information Technology	J INF TECHNOL	191	Information systems
British Medical Journal	BRIT MED J	183	Medicine
New England Journal of Medicine	NEW ENGL J MED	173	Medicine
Strategic Management Journal	STRATEGIC MANAGE J	170	Management
Communications of the Association for Information Systems	COMM AIS	168	Information systems
Harvard Business Review	HARVARD BUS REV	160	Management
Decision Sciences	DECISION SCI	159	Management
Journal of Strategic Information Systems	J STRATEGIC INF SYST	128	Information systems
Information and Organization	INFORM ORGAN	125	Information systems
Organization Studies	ORGAN STUD	117	Management
Information Systems Journal	INFORM SYST J	114	Information systems
MIT Sloan Management Review	MIT SLOAN MANAGE REV	112	Management
Journal of Marketing Research	J MARKETING RES	104	Management
International Journal of Information Management	INT J INFORM MANAGE	100	Information systems
Journal of the American Society for Information Science and Technology	J AM SOC INF SCI TEC	99	Information systems
Social Science & Medicine	SOC SCI MED	98	Social science; public, environmental & occupational health
Information Technology & People	INFORM TECHNOL PEOPL	95	Information systems
Journal of Applied Psychology	J APPL PSYCHOL	91	Psychology
Artificial Intelligence in Medicine	ARTIF INTELL MED	90	Computer science; health informatics
IEEE Transactions on Information Technology in Biomedicine	IEEE T INF TECHNOL B	85	Computer science
Journal of Medical Systems	J MED SYST	82	Health informatics
Annals of Internal Medicine	ANN INTERN MED	81	Medicine
Health Services Research	HEALTH SERV RES	80	Health service

Table H1. Journals Cited by Health IS Research

Journal of Biomedical Informatics	J BIOMED INFORM	80	Health informatics
Journal of Medical Internet Research	J MED INTERNET RES	77	Health informatics
Methods of Information in Medicine	METHOD INFORM MED	77	Health informatics
Journal of Management Studies	J MANAGE STUD	74	Management
Journal of Marketing	J MARKETING	73	Management
Journal of Telemedicine and Telecare	J TELEMED TELECARE	73	Health informatics
European Journal of Operational Research	EUR J OPER RES	68	Management
Health Care Management Review	HEALTH CARE MANAGE R	67	Health administration and management
Journal of Management	J MANAGE	66	Management
American Journal of Sociology	AM J SOCIOL	65	Sociology
Information Society	INFORM SOC	64	Information systems
Archives of Internal Medicine	ARCH INTERN MED	63	Medicine
Journal of Personality and Social Psychology	J PERS SOC PSYCHOL	63	Psychology
Information Systems Management	INFORM SYST MANAGE	62	Information systems
Human Relations	HUM RELAT	59	Management
Journal of Consumer Research	J CONSUM RES	59	Management
IEEE Transactions on Engineering Management	IEEE T ENG MANAGE	58	Engineering management
Medical Care	MED CARE	58	Medicine
MIS Quarterly Executive	MIS Q EXEC	53	Information systems
Journal of General Internal Medicine	J GEN INTERN MED	52	Medicine
International Journal of Human-Computer Studies	INT J HUM-COMPUT ST	50	Computer science
Computer Supported Cooperative Work-the Journal of Collaborative Computing	COMPUT SUPP COOP W J	49	Computer science
Information Systems Frontiers	INFORM SYST FRONT	49	Information systems
Psychological Bulletin	PSYCHOL BULL	48	Psychology
Journal of Computer Information Systems	J COMPUT INFORM SYST	47	Information systems
OMEGA-The International Journal of Management Science	OMEGA-INT J MANAGE S	47	Management
American Sociological Review	AM SOCIOL REV	46	Sociology
Expert Systems with Applications	EXPERT SYST APPL	46	Computer science
Lancet	LANCET	46	Medicine
Organizational Behavior and Human Decision Processes	ORGAN BEHAV HUM DEC	46	Management
Journal of Operations Management	J OPER MANAG	44	Management
Lecture Notes in Computer Science	LECT NOTES COMPUT SC	44	Computer science
Patient Education and Counseling	PATIENT EDUC COUNS	43	Public, environmental & occupational health
International Journal of Production Economics	INT J PROD ECON	42	Management
Journal of Healthcare Management	J HEALTHC MANAG	41	Health administration and management
Econometrica	ECONOMETRICA	40	Economics
ACM Transactions on Information Systems	ACM T INFORM SYST	39	Computer science; information systems
American Economic Review	AM ECON REV	39	Economics
California Management Review	CALIF MANAGE REV	39	Management
Marketing Science	MARKET SCI	39	Management
BMC Medical Informatics and Decision Making	BMC MED INFORM DECIS	38	Health informatics
Computers in Human Behavior	COMPUT HUM BEHAV	38	Psychology
Journal of Business Research	J BUS RES	38	Management
Science	SCIENCE	38	Multidisciplinary sciences
Journal of the Academy of Marketing Science	J ACAD MARKET SCI	35	Management
Machine Learning	MACH LEARN	35	Computer science

Table H1. Journals Cited by Health IS Research

Operations Research	OPER RES	35	Management
Research Policy	RES POLICY	35	Management
Data Base for Advances in Information Systems	DATA BASE ADV INF SY	33	Information systems
Computers & Security	COMPUT SECUR	32	Computer science
Social Studies of Science	SOC STUD SCI	32	History & philosophy of science
Telemedicine and E-Health	TELEMED E-HEALTH	32	Health service
International Journal of Electronic Commerce	INT J ELECTRON COMM	31	Management
Organization	ORGANIZATION	31	Management
Annual Review of Sociology	ANNU REV SOCIOL	30	Sociology
Information Systems	INFORM SYST	30	Information systems
Journal of Advanced Nursing	J ADV NURS	30	Medicine
Journal of Social Issues	J SOC ISSUES	30	Social science
Psychological Review	PSYCHOL REV	30	Psychology
IEEE Transactions on Knowledge and Data Engineering	IEEE T KNOWL DATA EN	29	Computer science
Canadian Medical Association Journal	CAN MED ASSOC J	27	Medicine
Journal of Health Economics	J HEALTH ECON	27	Economics
Academy of Management Annals	ACAD MANAG ANN	26	Management
Artificial Intelligence	ARTIF INTELL	26	Computer science
Journal of Service Research	J SERV RES-US	26	Management
Science Technology & Human Values	SCI TECHNOL HUM VAL	26	Social science
Computer	COMPUTER	25	Computer science
Computer Methods and Programs in Biomedicine	COMPUT METH PROG BIO	25	Computer science; health informatics
Journal of Computer-Mediated Communication	J COMPUT-MEDIAT COMM	25	Communication
Lecture Notes in Artificial Intelligence	LECT NOTES ARTIF INT	24	Computer science
Milbank Quarterly	MILBANK Q	24	Health service
Production and Operations Management	PROD OPER MANAG	24	Management
ACM Computing Surveys	ACM COMPUT SURV	23	Computer science
British Journal of Management	BRIT J MANAGE	23	Management
Sociology of Health & Illness	SOCIOL HEALTH ILL	23	Public, environmental & occupational health
Computers & Education	COMPUT EDUC	22	Computer science; education
IBM Systems Journal	IBM SYST J	22	Computer science
Journal of Applied Behavioral Science	J APPL BEHAV SCI	22	Management
Journal of Organizational Behavior	J ORGAN BEHAV	22	Management
Medical Journal of Australia	MED J AUSTRALIA	22	Medicine
Sociology-The Journal of the British Sociological Association	SOCIOLOGY	22	Sociology
Accounting Organizations and Society	ACCOUNT ORG SOC	21	Management
American Journal of Medicine	AM J MED	21	Medicine
American Journal of Public Health	AM J PUBLIC HEALTH	21	Public, environmental & occupational health
Information Processing & Management	INFORM PROCESS MANAG	21	Information systems
Long Range Planning	LONG RANGE PLANN	21	Management
Pediatrics	PEDIATRICS	21	Medicine
BMC Health Services Research	BMC HEALTH SERV RES	20	Health service
Computing	COMPUTING	20	Computer science
Health Policy	HEALTH POLICY	20	Health service
Journal of the American Statistical Association	J AM STAT ASSOC	20	Statistics

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