Electronic Medical Record Integration and Controversy:
Visualizing the Adoption of EMRs in the U.S.

Lindsay A. Carrabine

Drexel University, College of Information Science and Technology

Abstract—The integration of Electronic Medical Record systems into medical facilities in the United States is a controversial topic. The application of a computerized system aims to improve the quality of communication and documentation of medical records; however, some medical professionals are hesitant to adopt the technology. Through the evaluation of social media and co-citation network visualizations, this paper seeks to uncover trends in the dissatisfaction with EMRs and to compare discovered trends to current EMR related publications.

Index Terms—Electronic medical record (EMR), Electronic health record (EHR), Twitter/Tweets, co-citation network visualization

Introduction

An article written by Robert E. Hirschtick, provocatively entitled John Lennon's Elbow, inspired this exploration of EMRs [1]. In the article, Hirschtick discusses his frustration with the process for recording patient progress notes using EMRs. He observes that current practices distort the "traditional linear time line of medical storytelling into a nonlinear one," and explains, "when notes were written with pen and paper, writer's cramp kept entries succinct" [1]. Now keyboard entry allows users to "retain everything that has transpired during the hospitalization" in their notes [1]. This perspective of EMR implementation shows how the introduction of a new technology has added confusion to a previously transparent method for recording patient progress.

Frustration with EMRs is not unique to Hirschtick's experience. Minimal exploration into the realm of EMRs uncovers a wealth of information about adoption incentive plans and users' complaints about the current systems. In 2009, the U.S. Health Information Technology for Economic and Clinical Health Act authorized incentive payments to encourage physician adoption of EHR systems [2]. Adoption of EMRs by professionals in the medical field has increased since 2001, but the progress has been slow. Ideally, the interaction between a medical professional and an EMR system would be a seamless cooperative relationship. This research aims to explore the controversy of EMRs by connecting publications based on themes in topic discussion, location of publishing organizations, and the location of medical facilities that have adopted EMR technology.

1 Tools

1.1 Tweet Archivist

Tweet Archivist is a web application that can retrieve published user data from Twitter, a social network [3]. The application can gather Twitter data, or Tweets, from the previous week based on a key word or user name search. A user of this application can monitor new Tweets containing their selected key word and export the collected data as a spreadsheet. Tweet Archivist also generates a number of data visualizations based on top user analytics, key words, top URLs cited, and volume of Tweets over time.

1.2 Web of Science

The Web Of Science is an online database containing scientific publications developed by Thomson Reuters [4]. A user can gain access to the database by registering or entering the application through their university's library website. The Web of Science can be used to collect bibliographic records in scientific literature, based on a specific topic and search criteria.

1.3 Google Fusion Tables

Google Fusion Tables is an experimental public web application that can be used to gather, visualize, and share large data tables [5]. This application affords rapid development of mapping visualizations based on spatial data. Fusion Tables also makes public mapping data, such as United States boundaries, easily accessible for merging with other data sets.

1.4 CiteSpace II

CiteSpace II is an interactive visualization tool that network visualizations linking scientific publications that share citations [6]. After downloading and configuring CiteSpace II, a user can import a text-based bibliographic dataset on a topic of choice. CiteSpace II allows a user to manipulate unique mappings of co-citation clusters over a period of time, in order to analyze a topic, detect patterns in publications, and visualize how the topic has evolved in the research front.

2 Methods

2.1 Exploration of EMRs as a Controversial Topic

Prior to further exploration, the implementation of EMRs into medial facilities was validated as a controversial topic. Topic validation was confirmed by analyzing current trends in EMR related posting in social media. A search, using Tweet Archivist [3], for Twitter data including "electronic medical records" OR "EMRs" returned 887 Tweets published between March 9, 2013 and March 16, 2013. The top 3 cited URLs included:

> **94 Tweets** – Title: *Majority of doctors opposed to full access to your own electronic records*. Date: March 9,

2013. Content: Discusses a survey conducted by Harris Interactive of 3,700 doctors in 8 countries showing only 31% believe that patients should have full access to their own medical records .Link: http://arstechnica.com/tech-policy/2013/03/majority-of-doctors-opposed-to-full-access-to-your-own-electronic-records/

56 Tweets – Title: *EMRs cannot fix the financial and physical health of the nation*. Date: March 9, 2013. Quote: "Gathering data in health care seems to be a tall order is the lack of something called "interoperability", or in layman words "EMRs don't talk to each other." Link: http://www.kevinmd.com/blog/2013/03/emrs-fix-financial-physical-health-nation.html

50 Tweets – Title: *10 ways to make EMRs more doctor-friendly*. Date: March 13, 2013. Content: Suggests improvements including eliminating user names and passwords, getting rid of wires, developing voice-recognition software... Quote: "No wonder everyone hates electronic medical records (EMR)!" Link: http://www.kevinmd.com/blog/2013/03/10-ways-emrs-doctorfriendly.html

The most commonly shared URLs contain messages of dissatisfaction and controversy with EMRs. Two articles suggest the need for significant improvements in the current design of EMRs, and the article with the most Tweets discusses doctors' opinions on patient access to their own medical records.

2.2 Retrieving Published Records

Published reports containing data on EMR adoption rates by non-federally funded physicians in the U.S. were retrieved from the Center for Disease Control and Prevention's website [2]. Data was pulled from the report and saved as a spreadsheet for future visualization.

Content included a list of the States and the percentages of physicians that had implemented "Any" EMR or a "Basic" EMR. Any EMR was defined as the use of an electronic recording system for anything other than billing, and a Basic EMR was defined as an electronic system for recording patient records including medications, treatment plans, etc. The states with the highest adoption percentages by the end of 2012 were:

State	Any EMR %	Basic EMR %
Massachusetts	89.2	61.8
North Dakota	87	63.2
Hawaii	86.3	36.6
Minnesota	85.1	66.7
Iowa	85	54.9

Data was also gathered from the U.S. News' 2012-13 ranking of 156 hospitals that had high-performance rates and established leadership in the implementation of EMRs [7]. Ranking criteria included requirements from the U.S. Department of Health and Human Services and from the Healthcare Information and Management Systems Society [7]. The top five ranked hospitals included:

Hospital	Location	Rank
Mayo Clinic	Rochester, MN	1
University of Wisconsin Hospital & Clinics	Madison, WI	2
Stanford Hospital & Clinics	Stanford, CA	3
Ohio State University Hospital	Columbus, OH	4
Children's Hospital Boston	Boston, MA	5

Bibliographic records of publications relating to EMRs were retrieved using the Web of Science [4]. An initial topic search for "electronic medical record" OR "electronic health record" OR "EHR" OR "EMR", within a timespan of all available years, aimed to discover the most complete selection of articles relating to EMRs. The search returned 5,976 results. The results were then refined to only include articles published in the U.S. and from categories relating to health care science services, medical informatics, and computer science information systems. This reduced the results to 875 articles that were then sorted by the number of times the topic was cited from highest to lowest. The first 400 full records, including cited references, were exported as a plain text file and saved for later use with CiteSpace II.

After exporting the cited references, the Web of Science's analysis tool was used to create a quick visual analysis of the organizations with the most publications within the search results. The organizations in the U.S. with the most publications having to do with EMRs are:

Field: Organizations	Record Count	% of 875	Bar Chart
HARVARD UNIV	128	14.629 %	
BRIGHAM WOMENS HOSP	81	9.257 %	
INDIANA UNIV	44	5.029 %	
COLUMBIA UNIV	38	4.343 %	
UNIV UTAH	38	4.343 %	
MASSACHUSETTS GEN HOSP	35	4.000 %	
OREGON HLTH SCI UNIV	26	2.971 %	
VANDERBILT UNIV	26	2.971 %	
MAYO CLIN	25	2.857 %	
UNIV PITTSBURGH	25	2.857 %	

2.3 Visualizing Trends in EMR Adoption Data

Uploading the created data sheets, including information from the CDC and U.S. News, to Google Fusion Tables afforded a smooth process for creating transparent maps of the U.S. By merging the imported data with public mapping records,

map visualizations of the U.S. were created. These maps used a color gradient and markers to visualize percentages and locations of the highest ranked EMR adopters by state.

2.3 Visualizing Trends in EMR Publications

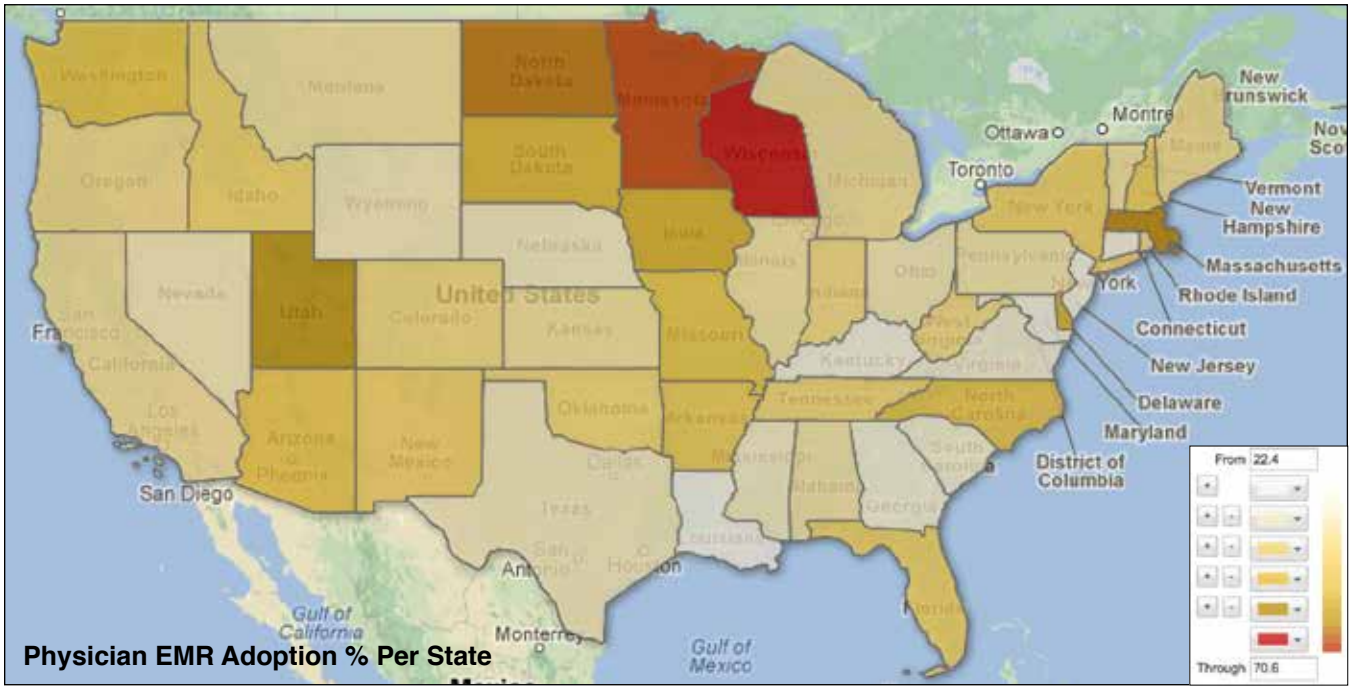
CiteSpace II generates intelligent visualizations of complex data sets and affords the detection and analysis of "emerging trends and abrupt changes" [6]. Importing the bibliographic EMR data set into CiteSpace II returned a dynamic interactive visualization. The goal of this co-citation network analysis was to clearly visualize the connections of citations and key words in order to discover unique and influential nodes.

The co-citation network visualization on EMR publications generated using CiteSpace II included nodes associated with cited references from the years 2004-2013. The visualization was explored using tools such as the visualization of citation bursts, the link walk through, increasing the node size, viewing the different labels of the clusters based on keywords and titles, and changing the node size based on centrality.

3 Results

3.1 Visualization of EMR Adoption

Two maps were created using Google Fusion Tables. The first map visualized the percentages of physician EMR adoption by state with the color red representing states with the highest adoption and the color white representing states with



the lowest adoption.

The second map visualizes location markers representing the 30 highest ranked hospitals with EMR adoption based on the report by U.S. News. The top ten hospitals have blue markers, the second ten have green markers, and the third ten have yellow.

3.2 EMR Cited Reference Network Visualization

The co-citation network visualization of EMR publications returned a large clustering of articles relating to the keyword "Bias." The five largest clusters in the network were :

Cluster #	Size	Index Terms
4	223	Bias, Quality measurement
9	14	Home health information technology
7	11	Schizophrenia,
6	10	Practice guideline, colonoscopy
2	7	Identifying hidden drug interaction

The synthesizing tool in CiteSpace II for summarizing a single cluster based on centrality was used to generate a collective abstract of cluster #4. A selection from the resulting summary stated: "Electronic health records (EHRs) are widely viewed as useful tools for supporting the provision of high quality healthcare, however, evidence regarding their effectiveness for this purpose is mixed."

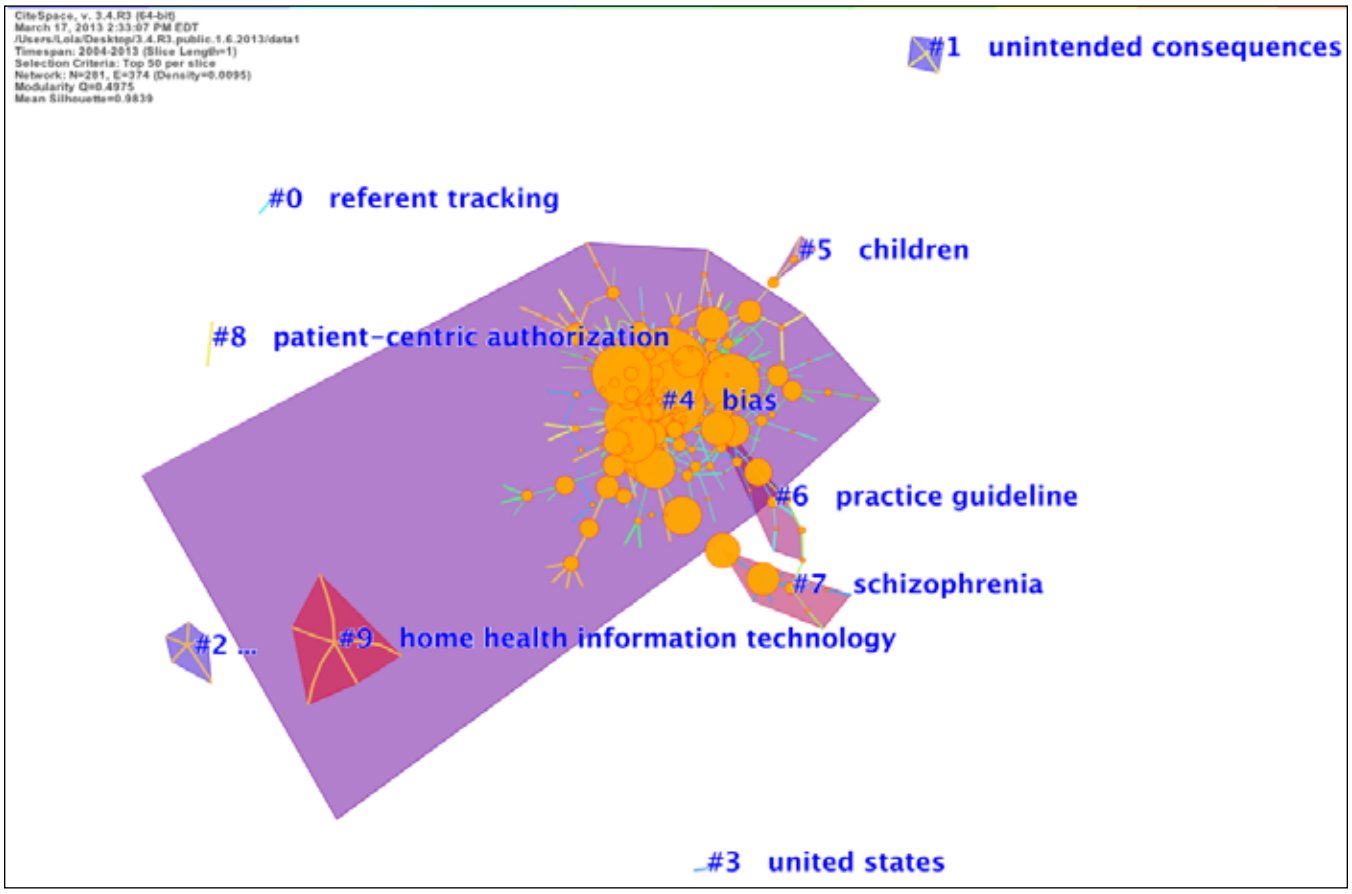
After confirming the presence of controversy with EMRs, the time line visualization generator was also used to confirm and explore the span of cluster #4. The presence of the "Bias" cluster was unrivaled in visual presence in both the network and time line views.

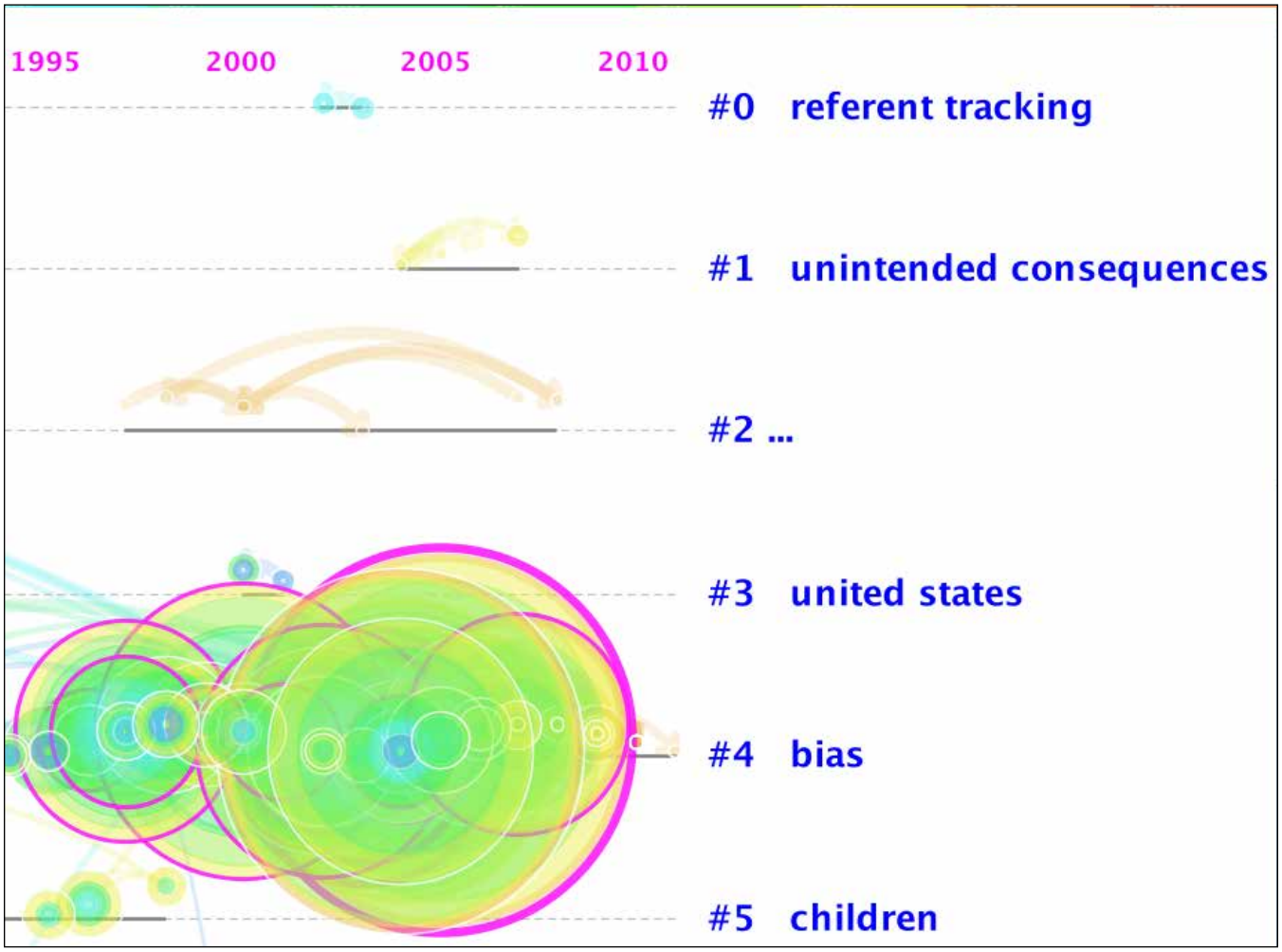
4 Interpretation

Exploration of social media, published records, and co-citation networks related to EMRs, uncovered a number of perspectives pointing to a hesitation in the adoption of EMRs. Maps with layered data showing adoption trends of EMRs did not show significant relationships between physician and hospital adoption. However, scientific publications relating to EMRs between the years of 2004-2013 show significant trends in bias towards EMRs. The implementation of a new system into a traditional field like medicine has introduced complications. Design for humans in any field, targeted to their intentions and meeting their needs, should focus on improving knowledge transfer and understanding.

5 Conclusion

There will always be some disadvantages to implementing a new technology, such as EMRs. In the end, the new technology must be significantly advantageous and improve a user's experience in order to justify the potential learning curve and paradigm shift. Today the adoption and implementation of EMRs in medical facilities is gathering momentum and has





the potential to "reshape the interface between people and information technology by offering new ways to communicate information, visualize processes, and express ideas" [8].

In the future, we may see EMRs evolve into interactive-multimedia systems, with the intention of increasing effective communication and documentation in medical facilities. For example, MIT Media Lab's Tangible Media Group is making impressive strides in augmented reality and interactivity. One of their projects, "Second Surface," shows how users can share "collaborative virtual spaces" in real-physical space through the use of tablet PCs [9]. In a medical environment, this kind of technology could be applied to patient treatment areas and provide medical professionals access to multiple layers of information about patient treatment plans and symptoms. In any medical environment there is a wealth of applicable knowledge. The medical industry can benefit from methods for improving communication between professionals.

References

[1] Hirschtick, R. E. (2012). John Lennon's Elbow. *JAMA, 308*(5):463-464. [PDF document]. Retrieved from: http://jama.jamanetwork.com/article.aspx?articleid=1273021

[2] Hsiao C. J., & Hing, E. (2012). Use and characteristics of electronic health record systems among office-based physician practices: United States, 2001–2012. NCHS data brief, no 111. Hyattsville, MD: National Center for Health Statistics.

[3] Tweet Archivist. (2013). [Software]. Available from: http://www.tweetarchivist.com/

[4] Thomson Reuters. (2013). Web of Knowledge: Web of Science (v.5.9) [Software]. Available from: http://apps.webofknowledge.com.ezproxy2.library.drexel.edu/WOS_GeneralSearch_input.do?SID=4F1LFdNk6BmfNe4oEN1&product=WOS&search_mode=GeneralSearch&preferencesSaved=

[5] Google Research. (2013). Fusion Tables [Software]. Available from: http://support.google.com/fusiontables/answer/2571232?hl=en

[6] Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology, 57*(3), 359-377.

[7] U.S. News. (Jul. 16, 2012). Most Connected Hospitals 2012-13. Retrieved from: http://health.usnews.com/health-news/most-connected-hospitals/articles/2012/07/16/most-connected-hospitals-the-list

[8] Stair, R.M. & Reynolds, G.W. (2012). *Fundamentals of Information Systems (6th Ed.)*. Boston, MA: Course Technology.

[9] Kasahara, S., Heun, V., Lee, A., & Ishii, H. (2012). Second Surface. Tangible Media Group. Retrieved from http://tangible.media.mit.edu/project/second-surface/