A Comprehensive Literature Review on Big Data in Healthcare

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Abstract

Big data in healthcare has drawn substantial attention in recent years. Current researches on big data in healthcare are highly interdisciplinary involving methodologies from engineering, computing, behavior science, information science, social science, management science, as well as many different areas in medicine and public health. However, the identification of major hot topics and related research methodologies in big data in healthcare still lacks a comprehensive quantitative analysis. To provide a better understanding of the hot topics and methodologies in big data in healthcare and their future trends, a systematic and comprehensive literature search of the published research papers from past 20 years in big data research of healthcare was conducted and the resulting 321 literature papers were reviewed and analyzed. Overall, we identified three major topics comprising of omics, medical specialties and IT healthcare, with 13 subtopics. We also classified the used methodologies into 7 types relating to different areas.

Keywords

Healthcare, big data, literature review, statistical analysis.

Introduction

Healthcare plays an important role in our societies. To improve the healthcare efficiency, accuracy and quality for people is a main goal set forth by both government and researchers. Over the decades, healthcare, medicine, surgery, and most other healthcare related activities have significantly increased and been improved(Adashi et al. 2010; Woolf et al. 2015). The explosion of big data provides a great potential for the improvement in healthcare domain. As defined, big data in healthcare refers to electronic health data sets that are too large and complex to be managed with traditional software or hardware; nor can they be easily managed with traditional or common data management tools and methods(Hansen 2014). The emerging research of healthcare big data varies with research methodologies and areas. Therefore, a comprehensive review of the healthcare big data is necessary to help understanding the status and trends of this promising area.

However, the current reviews either focus on a small area of healthcare big data, like telemedicine(Acheampong and Vimarlund 2014), health system(Olejaz et al. 2012), specific disease care(Cheung et al. 2015), or are limited to relative narrow range of time or sources(Baro 2015). Few
researches identify the major hot topics and research methodologies depending on a comprehensive and quantitative analysis.

To provide a better understanding of the hot topics and methodologies in healthcare big data and their future trends, a systematic search of healthcare big data related literatures published until December, 2015 was conducted. We identified three major topics, which are omics, medical specialties and IT healthcare, along with 13 subtopics based on 321 included papers. We also classified the methodologies used into 7 types referring to different areas.

The rest of this paper are organized as follows: first of all, we present the data collection and statistical description of the healthcare big data related papers. Then we identify three major topics and 13 subtopics, and provide a further analysis on the top 2 subtopics. Finally, we classify the used methodologies into 7 types relating to different areas.

**Material and Methods**

**Search Strategy**

Abundant studies have been conducted on traditional healthcare informatics. Healthcare Big Data refers to the problems arising with the emergent big data in healthcare. To ensure our selected Journals are related to the real healthcare big data, the following strategies are adopted:

Step 1: we use two sets of words, “large scale/ mass/ explosive/ big data”, and “healthcare/ health/ medic/ care/ clinic/ disease/ biomed”. Items composed of two words in each set are used as key words to search all the related papers published before December 2015.

Step 2: We select the papers whose title or abstract contains one of the items “large scale/ mass/ explosive/ big data” as well as one of the items “healthcare/ health/ medic/ care/ patient/ doctor/ hospital/ clinic/ disease/ epidemic/ biomed”, thus eliminating the papers mentioning but not actually meaning the word “health” or “big data”.

**Data Collection**

Based on the guidelines and suggestions from Hunter and Schmidt (1990) and Cooper (1998)(Cooper 1998; Hunter and Schmidt 1990), we used the following methods to search and identify source studies (from all the available studies before Dec 2015).

**Journal papers**

We searched all the computerized academic databases available at the XJTU library utilizing the key words already mentioned, namely EBSCO, Science-Direct, Sage Journals Online, ProQuest, JSTOR, Wiley InterScience, SpringerLink, Emerand, Fulltext.

**PhD dissertations**

We also searched ProQuest PhD dissertation database in the same way. Finally, four dissertations were identified as our meta-analysis source studies.

**Conference proceedings**

As we focus on the IS field, IS international conference proceedings, i.e., AMCIS, ECIS, ICIS, and PACIS, were also searched from the website “http: aisel. isworld.org/search.asp”.

**Working papers and complementary searching results**

Google Scholar, i.e. “http: scholar.google.com”, was also used to complement our search results. Furthermore, references potentially related to healthcare big data in several review papers(Acheampong and Vimarlund 2014; Kardas et al. 2013; Wang 2014) and aforementioned source papers were also traced.

Totally, 321 papers were included, the statistical analyses of which are shown in Table 1.
It can be drawn from Table 1 that the papers related to healthcare big data emerged at 2002 in the genomics area. Additionally, the number of publications related to healthcare big data grows rapidly since 2012. The increasing speed experiences a little decrease in 2015, which may because some of the paper’s published in 2015 were not obtainable.

Table 1 also shows some more details about the papers published. Almost 71% of our collected papers are journals while 27% of them are conferences. Few PHD dissertations and working papers are collected, which may result from the late emerging time and the bias of data source separately.

**Analysis and Classification**

As shown in Table 2, We wholly identified three major topics, namely omics, medical specialties and IT healthcare, including 13 subtopics based on 214 related papers. Papers mentioned healthcare big data but not focused on the specific area were excluded. The corresponding methodologies(Palvia et al. 2003) illustrated in Table 3 were also divided into 7 types. Interestingly, the percentage of medical specialties is only 14.1%, while there are 73.4% of papers focusing on the IT healthcare. The subtopic of Healthcare platform, system and mechanism accounts for 33.2% of all the papers, which is also the largest proportion among all the subtopics. The papers in this subtopic focus on several major themes, namely the safety and protection of the health system in big data environment(Liyanage 2012; Vargheese 2014), the design of a self-learning health system to provide a more accurate information support and low the cost of both the hospital and the patients(McClatchey 2015), the construction of the platform to provide a more efficient and accurate data processing mechanism(Abusharekh 2015). Additionally, the number of researches related to tools and facilities ranks second in all the 13 subtopics, about 14% of all the papers. They mainly introduce the emerging tools in big data era, like Apache, Hadoop, MapReduce, etc., and analyze the application and adjustment in the health system(Levy 2013; Wang 2015).

Based on Palvia’s (2013) introduction of methodologies(Palvia et al. 2003), we classified the methodologies used into seven categories, namely Laboratory Experiment, Case Study, Conceptual Model, Mathematical Model, Literature Analysis, Commentary and Others. Laboratory Experiment and Commentary make the maximum proportion among used methodologies, about 28% each. It may be due to the fact that healthcare big data, as an emerging area, attracts more and more attention. Researchers have been trying to figure out its meanings through reviews and remarks. In addition, Laboratory Experiment, as a kind of well controlled methodologies, is widely used to deal with big data problems. The percentage of Mathematical Model is 15.9%, ranking third among all methodologies.
### Field of study

<table>
<thead>
<tr>
<th>Field of study</th>
<th>Number of papers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omics</td>
<td></td>
<td>14.5%</td>
</tr>
<tr>
<td>Genomics</td>
<td>23</td>
<td>10.8%</td>
</tr>
<tr>
<td>Proteomics</td>
<td>8</td>
<td>3.7%</td>
</tr>
<tr>
<td><strong>Medical specialties</strong></td>
<td></td>
<td>14.1%</td>
</tr>
<tr>
<td>Endocrinology</td>
<td>6</td>
<td>2.8%</td>
</tr>
<tr>
<td>Imaging</td>
<td>4</td>
<td>1.9%</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>4</td>
<td>1.9%</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>10</td>
<td>4.7%</td>
</tr>
<tr>
<td>Neurology</td>
<td>6</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>IT healthcare</strong></td>
<td></td>
<td>73.4%</td>
</tr>
<tr>
<td>EHR</td>
<td>19</td>
<td>8.9%</td>
</tr>
<tr>
<td>Bioinformatics</td>
<td>13</td>
<td>6.1%</td>
</tr>
<tr>
<td>Web mining</td>
<td>10</td>
<td>4.7%</td>
</tr>
<tr>
<td>Telemedicine</td>
<td>14</td>
<td>6.5%</td>
</tr>
<tr>
<td>Healthcare platform, system and mechanism</td>
<td>71</td>
<td>33.2%</td>
</tr>
<tr>
<td>Tool&amp; facility</td>
<td>30</td>
<td>14.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>214</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table 2 Number of Paper by Fields

<table>
<thead>
<tr>
<th>Methodologies</th>
<th>Laboratory Experiment</th>
<th>Case Study</th>
<th>Conceptual Model</th>
<th>Mathematical Model</th>
<th>Literature Analysis</th>
<th>Commentary</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>61</td>
<td>15</td>
<td>12</td>
<td>34</td>
<td>28</td>
<td>60</td>
<td>4</td>
<td>214</td>
</tr>
<tr>
<td>Percentage</td>
<td>28.5%</td>
<td>7.0%</td>
<td>5.6%</td>
<td>15.9%</td>
<td>13.1%</td>
<td>28.0%</td>
<td>1.9%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3 Number of Different Methods

### Discussion and Conclusion

In this paper, we collected a total of 321 healthcare big data related papers published before December, 2015 through a large-scale search of healthcare big data related literatures. Then we selected 214 papers, which not only mentioned healthcare big data, but also describe a specific area of it. Based on them, we identified three major topics, omics, medical specialties and IT healthcare, along with 13 subtopics. It’s interesting to find that the percentage of medical specialties is only 14.1%, while there are 73.4% of papers focusing on the IT healthcare. In the subtopics level, the largest proportion of researches are related to healthcare platform, system and mechanism, accounting for 33.2% of all the papers. This subtopic can be classified into three major themes: 1) the safety and protection of the health system in big data environment, 2) the design of a self-learning health system to provide a more accurate information support and low the cost of both the hospital and the patients, and 3) the construction of the platform to provide a more efficient and accurate data processing mechanism.

We also classified the methodologies mentioned into 7 categories. Laboratory Experiment and Commentary make the maximum proportion in methodologies used, about 28% each. It may be due to the fact that
healthcare big data, as an emerging area, attracts more and more attention. Researchers have been trying to figure out its meanings through reviews and remarks. In addition, Laboratory Experiment, as a kind of well controlled methodologies, is widely used to deal with big data problems. The percentage of Mathematical Model is 15.9%, ranking third among all methodologies.

The results also suggest that research on healthcare big data is becoming more and more popular, especially in the topic on IT healthcare. Further analysis in the IT healthcare area, and on methodologies in specific subtopics will be proposed in our future study.

REFERENCES


