Development of medical informatics in China over the past 30 years from a conference perspective and a Sino-American comparison

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29 **ABSTRACT**

30 **Background:** As the world's second-largest economy, China has launched health reforms for the

31 second time and invested significant funding in medical informatics (MI) since 2010; however,

32 few studies have been conducted on the outcomes of this ambitious cause.

33 **Objective:** This study analyzed the features of major MI meetings held in China and compared

34 them with similar MI conferences in the United States, aiming at informing researchers on the

35 outcomes of MI in China and the U.S. from the professional conference perspective and

36 encouraging greater international cooperation for the advancement of the field of medical

37 informatics in China and, ultimately, the promotion of China's health reform.

38 **Methods:** Qualitative and quantitative analyses of four MI meetings in China (i.e., CMIAAS,

39 CHINC, CHITEC, and CPMI) and two in the U.S. (i.e., AMIA and HIMSS) were conducted.

40 Furthermore, the size, constituent parts and regional allocation of participants, topics, and fields

41 of research for each meeting were determined and compared.

42 **Results:** From 1985 to 2016, approximately 45,000 individuals attended the CMIAAS and CPMI

43 (academic), CHINC and CHITEC (industry), resulting in 5,085 documented articles. In contrast,

44 in 2015, 38,000 and 3,700 individuals, respectively, attended the American HIMSS (industry)

45 and AMIA (academic) conferences and published 1,926 papers in the latter. Compared to those

46 of HIMSS in 2015, the meeting duration of Chinese industry CHITEC was 3 vs. 5 days, number

47 of vendors was 100 vs. 1500+, number of sub-forums was 10 vs. 250; While compared to those

48 of AMIA, the meeting duration of Chinese CMIAAS was 2 vs. 8 days, number of vendors was 5

49 vs. 65+, number of sub-forums was 4 vs. 26. HIMSS and AMIA were more open, international,

50 and comprehensive in comparison to the aforementioned Chinese conferences.

51   **Conclusions:** The current MI in China can be characterized as "hot in industry application, and

52   cold in academic research." Taking into consideration the economic scale together with the huge

53   investment in MI, conference yield and attendee diversity are still low in China. This study

54   demonstrates an urgent necessity to elevate the medical informatics discipline in China and to

55   expand research fields in order to maintain pace with the development of medical informatics in

56   the U.S. and other countries.

57

59 **INTRODUCTION**

60 **Development of the Discipline of Medical Informatics**

61 Medical informatics (MI) is a multidisciplinary field in which researchers pursue scientific

62 exploration, problem-solving, and decision-making to facilitate the effective use of biomedical

63 data, information, and knowledge for the improvement of human health (Kulikowski et al. 2012).

64 First proposed in 1970 (Haux 2010), medical informatics currently includes 20 subfields, such as

65 clinical informatics (Kulikowski 2007; M.J.Sehuemie et al. 2009); over time, the focus of MI

66 research has shifted from hardware and software innovation to software systems and

67 information-processing models, particularly data and knowledge description and management,

68 computerization, and evaluation (Kulikowski 2007). Medical informatics has been recognized

69 worldwide as an emerging, independent, and important interdisciplinary field.

70

71 **High-level Design and Industry Development of Hospital Informatics in China**

72 Rapid economic development and recent health care reforms in China have greatly facilitated the

73 development of hospital informatics. In 2010, as China became the world's second-largest

74 economy, the Chinese government initiated its second health care reform, which is the largest

75 since the founding of the P. R. China, with an announcement that "medical information systems

76 and population health informatics" would be one of the "four pillars, eight posts" supporting

77 reforms in the health care field (Qun 2011). Guided and stimulated by these policies, the Chinese

78 government and healthcare informatics users have made substantial investments in population

79 health informatics and hospital informatics. During the past and 12th 5-year plan, encompassing

80 the period between 2011 and 2015, the Chinese government began investing a considerable

81 amount of money for the purpose of promoting the construction of health information. The

82 central government alone directly appropriated 1.5 billion US dollars for village-level and

83 county-level information construction projects in the Midwest region's 22 provinces. The former

84 included health information system construction for primary health care institutions covering all

85 the public Township and community health institutions; in addition, the central government

86 invested 45 million US dollars for the health information projects of 16 health care reform pilot

87 cities, 120 million US dollars for 16 provincial information platform construction projects, and

88 60 million US dollars for telemedicine information system projects covering 22 provinces. By

89 2020, the government will further invest more than 3 billion US dollars for the "national

90 electronic health information systems engineering" project(Hu J et al. 2016). In 2015, the market

91 of hospital informatics alone reached 5 billion US dollars; by 2020, this market is projected to

92 exceed 14.5 billion US dollars, at an annual compound growth rate of $\geq 24\%$ (Luo 2014).

93   Given the space limitations of this paper, readers may refer to Appendix A-1 (*Evolution of*

94 *Hospital Informatics in China*) if interested in additional information.

95

96 **Development of the Medical Informatics Discipline in China is relatively behind that of the**

97 **U.S.**

98 In China, the discipline of medical informatics is primarily characterized by a mismatch between

99 the developmental model and hospital informatics. Medical informatics had a late start, with

100 roots in traditional medical information and library science. Originating in China during the

101 1970s, this discipline has been evolving for over three decades (LI & LIU 2014). Because

102 various biomedical and computer technologies are widely used in the medical field in China, the

103 research focus of medical informatics has expanded from library informatics and information

104 technology at information organizations, to information theory research, business systems, and

105   the construction and application of infrastructure in the medical field. At present, medical

106   informatics research in China focuses on Health Information Technology (HIT)-related

107   organizations and includes HIT application and evaluation (e.g., hospital information systems);

108   medical information research and services; and medical information resource development,

109   retrieval, and services. Hospital information systems are primarily implemented and applied by

110   each hospital; medical information research and services are the major obligation of medical

111   information research institutes; and medical information resources development, retrieval, and

112   services are the major obligation of medical libraries.

113   An evolving interdisciplinary subject in China, medical informatics (MI) remains relatively

114   backward; until recently, the concept was not clearly defined or widely accepted (Lei et al. 2016).

115   As with any discipline, MI requires systematic support—inclusive of related mainstream journals,

116   publications, agencies, associations, and academic institutions—in order to become established

117   and advance (Dong 2004). However, as mentioned previously, medical informatics in China is

118   subject to the influence of traditional medical information and library science, as well as

119   historical and other challenges. Nevertheless, with rapid economic growth, the importance that

120   the government ostensibly places on the development of medical informatics—in the form of

121   government-led top design and huge investments—and China's myriad medical institutions and

122   its massive population, there is now an unprecedented opportunity for medical informatics to

123   successfully evolve. To this end, it will be important to strengthen international cooperation so

124   that China and other countries may learn from one another and promote the development of

125   medical informatics.

126   This paper focuses on four national mainstream medical informatics conferences and

127   compares their data with the data from two international medical informatics conferences based

128   in the U.S. (i.e., the AMIA[1] and HIMSS meetings). This aims to explore the differences and

129   identify the lessons learned in order to aid Chinese researchers and their international colleagues

130   in understanding the characteristics of medical informatics in China and how progress might be

131   made. Here, the overall goal is sharing China's experience with other countries, for the purpose

132   of promoting the exchange of knowledge worldwide for the improvement of China's medical

133   informatics as well as that of other nations, if possible, that are likely to lag in the discipline.

134

135

136   **BACKGROUND**

137   **Mainstream Chinese Medical Informatics Conferences and Their Evolution**

138   There are four mainstream Chinese medical informatics conferences: the China Hospital

139   Information Network Conference (CHINC), the Chinese Medicine Information Association

140   Annual Symposium (CMIAAS), the China Proceedings of Medical Informatics (CPMI) and the

141   China Health Information Technology Exchange Conference (CHITEC). Basic information on

142   these four conferences is presented in Table 1 below.

143   [**Table 1** insert here]

144   Please refer to Appendix A-2 (*Evolution of Chinese Mainstream Medical Informatics*

145   *Conferences*) for more information regarding these conferences, including descriptions of these

146   conferences, related organizations and their URLs.

147

148

149   **MATERIALS AND METHODS**

[1] Including annual symposium and joint summits, for the sake of convenience, together as
AMIA.

150 **Selection of Mainstream MI conference in China**

151 According to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-

152 Analysis) method (Moher et al. 2009), the selection criteria are defined as follows:

153   1. The academic topics of the meeting must be related to medical informatics, including but

154 not limited to: clinical informatics, bioinformatics, drug informatics, nursing informatics, public

155 health informatics, medical image informatics, etc.;

156   2. The meeting must be organized by a national academic organization or international

157 academic organization in China;

158   3. The meeting must call for papers through academic journals or an international open

159 approach;

160   4. The meeting must be continuous and have been held at least 5 times.

161   5. The meeting must have a certain degree of visibility, academic credibility and influence

162 in China's medical informatics community.

163   Ultimately, we chose 4 HIT meetings as the major meetings in mainland China, namely:

164 CMIAAS hosted by CMIA (the only country representative of IMIA), CPMI hosted by CSMI,

165 CHINC hosted by CHIMA and CHITEC hosted by CHIA.

166

167 **Collection of Data**

168 China's top three biggest literature databases were searched: the VIP database of Chinese

169 scientific and technical journals , the Chinese National Knowledge Infrastructure, and the

170 Wanfang data retrieval platform. These databases were searched for "会议论文集 (meeting

171 proceedings)." Keywords included the Chinese name of the conference (中国医药信息学大会

172 [CMIAAS], 中华医院网络信息大会 [CHINC], 中国卫生信息技术交流大会 [CHITEC],

173 and 中华医学会全国医学信息学术会议 [CPMI]), the Chinese organizer of the conference (中

174 国医药信息学会 [China Medical Informatics Association] [CMIA], 中国医院协会信息管理

175 专业委员会 [the Committee on Information Management, Chinese Hospital Association]

176 [CHIMA], 中国卫生信息学会 [China Institutes of Health Information] [CHIA], and 中华医学

177 会医学信息分会 [the Medical Informatics Branch, Chinese Medical Society] also known as

178 [Chinese Society of Medical Information] [SCMI]), as well as the English acronym of each

179 meeting (CMIAAS, CHITEC, CHINC, and CPMI). Meeting proceedings between 1985 and

180 2015 were retrieved. Furthermore, related supporting information, together with biographical

181 references, was also searched, such as the purpose, business scope, and "call for papers" about

182 each meeting.

183   Data about the Healthcare Information and Management Systems Society (HIMSS) and the

184 American Medical Informatics Association (AMIA), which are the two major U.S. medical

185 informatics meetings, were obtained from literature reviews (Fickenscher 2013a; Fickenscher

186 2012a; Fickenscher 2012b; Fickenscher 2013b; Fickenscher 2013c; Fickenscher 2013d;

187 Middleton 2014; Ravvaz et al. 2015; Shortliffe 2011a; Shortliffe 2011b) as well as the "letter of

188 welcome" for AMIA and HIMSS and websites about meeting organizers.

189

190 **Extraction of Data**

191 Information about target meetings from the literature and databases was exported, for instance:

192   1. Meeting size, including the meeting's name, who held it and when it was held, its

193 schedule, the duration, the number of participants, etc.

194   2. General information regarding the proceedings, for instance, title, author affiliation,

195 publication year, meeting name, and where the author lives (a self-developed tool is extracted).

196   3. Subjects of conference proceedings were gathered and analyzed, in addition to the "call

197   for papers" of the CMIAAS, CPMI, CHINC, and CHITEC (2000-2015) and the organizer's

198   business scope. According to the results, these meetings mainly dealt with highly similar topics

199   in 10 fields of research, including but not limited to hospital informatics, regional as well as

200   grassroots health informatics and telemedicine.

201

202   **Data Analysis**

203   EndNote X7, EXCEL 2011, and Python were used for a preliminary analysis of the general

204   information assembled, along with proceedings topics. The results of the analysis were described

205   from the perspective of the actual developmental circumstances of medical informatics and HIT

206   in China.

207

208

209   **RESULTS**

210   **Overall Volume and Trend of Conference Proceedings**

211   We searched three mainstream Chinese databases and retrieved a total of 6,681 papers from the

212   proceedings of four conferences (1985 to 2015). For the purposes of this study, we intentionally

213   selected conference proceedings published after 2008 because most conference papers (76%,

214   5085 papers) were published on or after 2008, when publication and database entries for medical

215   informatics conference proceedings became more standardized and comprehensive in China.

216   This choice contributed to the alignment and data analysis of the proceedings. Moreover, during

217   that time, the Chinese government was preparing to propose its "second health care reform," and

218   HIT application was about to burst onto the scene.

219   [**Figure 1** insert here]

220   Figure 1 shows Chinese MI conference proceedings trends, by conference, from 2008-2015,

221   excluding some unavoidable gaps. It can be seen clearly that the growth rate of industry

222   conference submission is much higher than that of academic conferences, and CMIAAS even

223   had negative growth. The overall trend of papers published in various Chinese MI conferences

224   demonstrated a tendency of "hot in industry application, and cold in academic research". In

225   addition, We observed that the CPMI proceedings were incomplete (i.e., the CPMI-2013 was

226   missing) and, for CHINC and CHITEC, a large percentage of the proceedings were missing,

227   including the CHINC 2009-2011 and 2013, as well as CHITEC 2009, 2010, and 2012. We

228   conducted preliminary descriptive statistical data analysis for each conference, with a focus on

229   the continuity of proceedings entries in the literature databases. Note that, in PubMed, all AMIA

230   proceedings since 1977 (annual symposium) and 2008 (joint summits) are available for

231   download free-of-charge; in China, however, databases for the four mainstream medical

232   informatics conferences are neither continuous nor unified, and downloading is not

233   complimentary. Literature articles were distributed among three different databases, and some

234   proceedings were downloadable only from the conference's association website.

235   In addition, we examined conference and editorial reviews of the proceedings and observed

236   that, unlike international mainstream medical informatics conferences (e.g., AMIA), which

237   implement a rigorous review process for submitted manuscripts (Kulikowski 2007), Chinese

238   medical informatics conferences have yet to implement a process of peer-review for submitted

239   papers, in most cases, only style and formatting requirements checking had been done; For some

240   MI conferences in China, the acceptance rate was higher than 90% (Li 2015; Ya-min et al. 2011;

241   Yajie et al. 2015; Yajie et al. 2014). The main reason for such few submission and high

242   acceptance is likely due to a weak foundation for medical informatics and an insufficient pool of

243   qualified peer-reviewers.

244

245   **Number of Attendees and Trends**

246   To compare the number of submitted conference papers and align the data across different

247   conferences, we collected relevant information on all conference sessions from each conference

248   website, as well as corresponding association websites. Note that CHITEC'16, CHINC'16, and

249   CPMI'16 had finished, but the organizers have released on their homepages only attendance

250   information such as number of participants, while the proceedings are not available in these

251   databases. For CHITEC'16, CHINC'16, and CPMI'16, we have only the number of participants

252   in the comparisons. Figure 2 depicts the trend of conference attendees from 2008-2016,

253   excluding CMIAAS (2008-2015), showing that the number of attendees declined slightly at

254   CMIAAS and increased by only 140 from 2008-2016 at CPMI. By contrast, the number of

255   attendees increased dramatically at CHINC and CHITEC, by 3.9-fold and 8.3-fold, respectively,

256   over 2008-2016, which is consistent with results described in this section. It is within expectation

257   that the number of attendees was highly consistent with the trend of published proceedings,

258   further confirmed the characteristic of Chinese MI development, "hot in industry application, and

259   cold in academic research".

260   [**Figure 2** insert here]

261

262   **Source of Conference Proceedings: Types of First-author Affiliations**

263   Author affiliations were selected according to the requirements delineated in each conference's

264   "call for papers," inclusive of medical institutions, universities, research institutions, and

265   manufacturers. We referenced similar international evaluations and focused on first-author

266   affiliations, which proved to be a good indicator of each type of first-author affiliation. Figure 3

267   shows the type and percentage of first-author affiliations (% all affiliations) among available

268   conference proceedings from 2008-2015.

269   [**Figure 3** insert here]

270   Figure 3 shows a clear trend of author affiliations for four Chinese mainstream medical

271   informatics conferences:

272   1. Most attendees (indirectly inferred from the distribution of authors because of data

273   availability) of Chinese medical informatics conferences (CMIAAS, CHINC, CHITEC, and

274   CPMI) were from "medical institutions," which differed from the attendees of annual HIMSS

275   and AMIA conferences; most AMIA conferences attendees were from universities and research

276   institutes, and the largest HIMSS attendee group was software providers in the HIT industry.

277   Moreover, significantly more attendees were from "medical institutions" than from other

278   institutions, whereas 78.3% of attendees at the CHINC were from medical institutions, which

279   may reflect the purpose of the organizer, China Hospital Information Management Association

280   (CHIMA), which focuses on domestic and foreign hospital information management. At the

281   CMIAAS, 33.2% of attendees were from universities, which is consistent with MEDINFO

282   attendees (Kulikowski 2014). CHITEC is a semi-official mainstream Chinese medical

283   informatics conference; thus, many attendees (> 25%) were from "health administrative

284   authorities." At the CPMI, attendees were evenly distributed among the various entities; such

285   representation was most likely because the organizer SCMI was initially focused on traditional

286   medical information and library science and information services—therefore, attendees

287   represented universities, research institutes, or medical institutions. Unlike HIMSS, few

288   attendees representing manufacturers submitted first-author papers to Chinese medical

289   informatics conferences. At CHINC, 13.9% of attendees were manufacturers, whereas at the

290   other three conferences, the percentage was $\leq$ 7%. Here, we use the distribution of the first

291   author of the conference paper to simulate the distribution of the actual participants, because the

292   accurate data of the actual participants can only be obtained from the various organizers and

293   cannot be obtained from the public channels.

294   2. The AMIA and HIMSS conferences represent two different medical informatics

295   exchange platforms: academic research (AMIA) and HIT application (HIMSS). Among

296   mainstream Chinese medical informatics conferences, CHINC and CHITEC are similar to

297   HIMSS and its focus on HIT applications. Most CHINC and CHITEC attendees were from

298   medical institutions or administrative authorities, and the scale of these conferences was also

299   large; in 2015, 667 papers were included in CHITEC proceedings and 853 in CHINC

300   proceedings. Similar to AMIA, the CMIAAS and CPMI are medical informatics conferences that

301   focus on academic exchange, as well as some HIT applications; most attendees were from

302   medical institutions, and some attendees were from universities and research institutes. Their

303   scale was much smaller; in 2015, only 70 papers were included in CMIAAS proceedings and 248

304   in CPMI proceedings. We compared the scale and attendee affiliations for these two types of

305   conferences and observed that, even at academic conferences, the percentage of attendees from

306   research institutes remained relatively low and that most papers focused on information systems

307   application in medical institutions. This information provided indirect evidence for the

308   postulation that "HIT is popular in industry application but unpopular in academic research in

309   medical informatics" (Lei et al. 2016).

310

Geographic Distribution of Conference Proceedings First Authors

We also analyzed the geographic distribution (e.g., municipality, province, etc.) of practitioners

and researchers attending the previously described conferences from 2008-2015. Figure 4 shows

the distribution of first authors (percentage, by geographic area) for each of the conference

proceedings. The top three provinces and/or municipalities were selected, as shown below:

[**Figure 4** insert here]

The academic disciplines and industry HIT development in different provinces and cities

are unbalanced, showing the characteristics of "strong coastal areas in the East and weak inland

areas in the West". This is because that comprehensive giant medical institutions, high-level

medical information systems providers, research institutions are concentrated in a small number

of eastern densely populated, medical and educational resources rich, economically developed

municipalities and provinces.

We further compared and analyzed the statistics in Table 1 (above), and concluded the

following:

1. Not surprisingly, Chinese medical informatics conferences were more regional and local

than those of AMIA and HIMSS; that is, most papers were submitted by first authors from a

small number of provinces and municipalities; other papers were submitted by authors outside

Mainland China (as noted by the designation "Others"). Among the top contributors (provinces

and municipalities) to these four conferences, Beijing and Sichuan were in three of the "top

three" lists, and Jiangsu was in two of the "top three" lists. Because Beijing is the capital of

China (CHINA 2014a), this ranking was expected; Sichuan (Shi & Zheng 2008) and Jiangsu

(CHINA 2014b) are economically developed areas with abundant medical, scientific, and

technological resources and an active and mature HIT market. In addition, unlike international

334   mainstream medical informatics conferences (e.g., AMIA and HIMSS) (Maojo et al. 2012), few

335   practitioners or researchers outside Mainland China submitted papers to Chinese medical

336   informatics conferences. Because the international influence of China's medical informatization

337   is still very weak, the current positioning of these conferences is only as domestic conferences.

338   Everything from the conference themes and service targets to the contents of publications

339   reflects Chinese characteristics, and the conference exchange language is also Chinese.

340   2. Consistent with the economic development in different regions of China, the geographic

341   distribution of attendees was also highly uneven. For all four conferences, more than one-third of

342   attendees were from the top three provinces and/or municipalities ($\geq 50\%$ at CMIAAS and

343   CHINC), indicating that, overall, less than half of the attendees were from the remaining 29

344   provinces, which is evidence of the uneven development of academic research and HIT

345   applications in medical informatics throughout various regions of China.

346

347   **Distribution of Conference Proceedings Topics**

348   We browsed titles and abstracts of conference proceedings and classified papers for topic areas

349   and statistically analyzed the results. We believe that the percentage of different topics covered

350   in conference proceedings provides indirect evidence of current hot and cold topics in Chinese

351   MI academic research and HIT application. The primary results (i.e., the distribution of topics for

352   CMIAAS, CHINC, CHITEC, and CPMI conference proceedings [2008-2015]) are shown in

353   Figure 5.

354   [**Figure 5** insert here]

355   Figure 5 shows the following characteristics related to the distribution of HIT applications

356   and research areas among the four Chinese mainstream medical informatics conference

357   proceedings:

358   1. "Health Information Technology (HIT) is popular in industry application but unpopular

359   in academic research for medical informatics." Specifically, more than 50% of topics for the four

360   conference proceedings were related to HIT applications in medical institutions and population

361   health informatics, such as "hospital informatics" and "public and regional, and grassroots health

362   informatics as well as telemedicine." These topics are consistent with the "four pillars, eight

363   posts" policies of current health care reform in China, which has driven substantial investments

364   in hospital and population health informatics.

365   2. Unlike topics in AMIA conference proceedings (Maojo et al. 2012), we observed few

366   topics (as low as < 1%) in "medical informatics theory," "biomedical cognitive science," or

367   "standards, safety, legal, and related issues" in CHINC, CPMI, and CHINC conference

368   proceedings, and these topics were in AMIA's Call for Papers. Moreover, many areas in AMIA

369   and HIMSS conference proceedings, such as "dental informatics" and "consumer health

370   information," were not referenced in the "call for papers" of the four mainstream Chinese

371   medical informatics conferences. This dearth reflects the gap between the breadth and depth of

372   MI academic research as well as HIT applications in China and the U.S.

373

374

375   **DISCUSSION**

376   **MI Conference Proceedings in China: Some General Observations**

377   1. Weak foundation for MI. In China, the early-stage development of medical informatics

378   was dominated by library science and information, with no support from computer science and

379   information technology (Lei et al. 2016); thus, the state of the medical informatics discipline in

380   China is currently behind that of the U.S. and, potentially, other countries.

381   2. Missing subfields in the medical informatics discipline. Given the internationally

382   recognized categories of subfields in medical informatics, certain subfields remain missing or

383   under-developed in China.

384   3. The difficulty of using theories to solve practical issues. Few theoretical research studies

385   about medical informatics in China have been carried out, despite the numerous publications in

386   this field. Currently, graduate programs in medical informatics are available in only a few

387   Chinese teaching institutions.

388   4. Academic institutions in China cannot provide adequate numbers of sufficiently qualified

389   professionals to apply their knowledge of medical informatics in industry (e.g., hospital

390   information technology departments).

391   Due to the space limitations of this paper, readers may refer to Appendix A-3 (*Unique*

392   *Characteristics of the Medical Informatics Discipline in China*), if interested in further

393   information.

394

395   **MI Conferences in China and the U.S.: Further Analysis and Comparisons**

396   For more in-depth investigation of China's current research in medical informatics, the

397   application of HIT, meeting sessions, and the number of participants, subjects discussed at

398   meeting proceedings, academic research, and real-world applications as well as presentations of

399   academic achievements, participating vendors, and review criteria in China's four major medical

400   informatics meetings (i.e., CMIAAS, CHINC, CHITEC, and CPMI, 2015), together with

401   preparation of AMIA (annual symposium and joint summits) and HIMSS (2015) are presented.

402   Figure 6 and 7 throw light on the results, and Table 2 brings forth the specific details.

403   [**Figure 6** insert here]

404   [**Figure 7** insert here]

405   [**Table 2** insert here]

406   We analyzed the data in table and figures to reach the main conclusions regarding the

407   status quo of the development of medical informatics in both China and America:

408   1. According to the cross-field research about the quantitative measures of Sino-U.S.

409   academic and industrial exchange meetings, there is a huge gap between the two countries in

410   terms not only of HIT applications but also of MI academic research.

411   1.1. In terms of academic exchange meetings, we compared the relatively large CPMI

412   meeting (2015) with that of the AMIA (including the annual symposium as well as joint

413   summits, 2015) and counted the number of participants as well as meeting papers of the

414   CPMI, which were only approximately 8% of the total number of AMIA meeting papers.

415   For the formats of demonstrating academic achievements, academic achievements were

416   demonstrated at AMIA 2015 in a variety of ways, for instance, system demonstrations, full-

417   text papers, student papers, posters, abstracts, design contests, and descriptions; however, at

418   CPMI 2015, academic achievements were demonstrated in merely two ways: full-text as

419   well as exchange papers. Among these topics, discussions were carried out on merely 7

420   fields at CPMI 2015, and 70.6% of papers were associated with information retrieval as

421   well as hospital informatics; on the contrary, all of the 20 sub-fields associated with medical

422   informatics were transferred at AMIA 2015.

423   1.2. Regarding HIT application meetings, the gap was huge as well. Our comparison of

424   the relatively large CHITEC 2015 as well as HIMSS 2015 showed that the number of

425   participants at CHITEC 2015 was just 10% of that at HIMSS 2015 (3,500+ compared to

426   38,000+); the number of participating vendors at CHITEC 2015 was only approximately

427   8.3% of that at HIMSS 2015 (100+ compared to 1,200+). Academically, as respects value-

428   related measures, CHITEC 2015 included merely 10 forums and 87 lectures on continued

429   education, just 4% and 33%, respectively, of the forums and lectures at HIMSS 2015 (250+

430   forums together with 300+ continuing education lectures over 4 days). In terms of topics, 10

431   fields were transferred at CHITEC 2015, but 73.8% of meeting papers were associated with

432   population health informatics or hospital informatics; in contrast, all 20 sub-fields

433   associated with medical informatics were discussed at HIMSS 2015.

434   2. A significant gap between the academic value of Chinese and American MI meeting

435   proceedings papers was also noted. To be more specific, at Chinese HIT meetings, in most

436   cases,only format review was carried out because of insufficient submitted papers and well-

437   rounded peer reviewers who were trained in medical informatics courses. Therefore, the Chinese

438   conference papers' academic value might be relatively low. In contrast, strict peer-review was

439   carried out for AMIA 2015. According to the data available on the website, AMIA's proceedings

440   papers' acceptance rate is lower than 30%; consequently, AMIA is identified by the China

441   Computer Federation Academic Committee as "a significant internationally recognized

442   meeting"(Committee 2015). In addition, in order to further determine the academic value of

443   Sino-American medical information conferences, we take CPMI '15 and AMIA' 15 as an

444   example, we use the Wanfang data retrieval platform and the PUBMED Central database to

445   query paper citations. We found that the 248 CPMI '15 conference papers were cited 15 times, of

446   which only 1 papers were cited 2 times, and 13 papers cited 1 times, with an average citation rate

447   of 0.06. However, the 225 full-text articles from AMIA '15 were cited 67 times, of which 1 paper

448   was cited 4 times, 1 paper cited 3 times, 9 papers cited twice, 42 papers cited once, with an

449   average citation rate of 0.3 times per paper, this is 5 times that of CPMI' 15.

450   3. It is a known fact that the big gap in MI conferences between the United States and China

451   is closely associated with their economic strengths and populations as well as their health care

452   systems. 2015 statistics reveal that the United States GDP is 1.78 times that of China (18.04

453   trillion US dollars (OECD 2017a) vs. 10.14 trillion US dollars (Chinese 2014a)), whereas its

454   population is only 23% of the latter (314 million (OECD 2017c)vs. 1.37 billion (Chinese

455   2014c)). However, the United States' expenditure on health care is 16.9% of its GDP(OECD

456   2017b), while that of China is 5.95% (Chinese 2014b). This means that, in the same year, the

457   United States' per capita health expenses amounted to 9451 US dollars (OECD 2017b), whereas

458   Chinese healthcare expenses per capita were only 438 US dollars (Chinese 2014b); the former is

459   21.6 times that of the latter. Moreover, the large gap between the Chinese health system and that

460   of the U.S. suggests that, in the U.S., new inventions are quickly applied (Deaton 2015). MI, as a

461   new interdisciplinary field with a naturally broad market prospect, has gathered a good amount

462   of investment funding and support, whereby investors would like to use new technologies to

463   reduce medical expenditures, forcing medical institutions to control costs while also

464   guaranteeing quality healthcare. Thus, it is no surprise that the number of participants of HIMSS

465   (2015) is 10 times that of CHITEC (2015), and AMIA (2015)'s academic achievements are 7.8

466   times those of CPMI (2015). This huge gap implies great room for collaboration between

467   Chinese MI professionals and their U.S. counterparts. For further detailed descriptions, please

468   see Appendix A-3 *(Unique Characteristics of Medical Informatics Discipline in China)*.

469

470

471 **CONCLUSION**

472   In China, medical informatics began in the 1970s and was based on library information

473 science. In contrast, in the U.S., medical informatics is based on computer applications in

474 medicine. At present, a large gap between China and the U.S. exists with respect to research

475 rigor and direction, regional balance in the development of medical informatics disciplines, and

476 the breadth and depth of academic research and industry application. These conclusions are

477 based on our analysis of four Chinese mainstream MI conference proceedings, as well as two

478 major U.S. MI conference proceedings.

479   In addition, the Chinese medical education curriculum initially focused on "medical

480 literature information systems," which was significantly different from the framework of the

481 medical education curriculum in the U.S. and other countries. This difference was demonstrated

482 in CPMI proceedings paper topics.

483   Finally, some relatively large Chinese medical informatics organizations (e.g., CHIMA,

484 SCMI, and CHIA) are not currently IMIA members; CMIA, the only current IMIA member, was

485 previously a secondary institution of the Chinese Institute of Electronics. Consequently, the

486 public status of CMIA, diverging from library information science-based medical informatics, is

487 second only to that of SCMI in the academic community, but compared with CHIMA and CHIA,

488 its business sponsors and attendees are much fewer. Moreover, communication between

489 CHIMA, which focuses on hospital informatics, and CHIA remains a challenge.

490   This study demonstrates an urgent necessity to elevate the medical informatics discipline in

491 China and to expand research fields in order to maintain pace with the development of medical

492   informatics in the U.S. and other countries. To this end, the authors propose four suggestions: 1)

493   the central Chinese government should establish developmental goals and strategies for the

494   medical informatics discipline; 2) the government should support the integration of medical

495   informatics research with national health informatics; 3) according to international guidelines for

496   medical informatics education prescribed in the latest version of IMIA (Haux & Murray 2010;

497   Mantas et al. 2010), a framework based on these guidelines and actual conditions in China

498   should be developed to define the professional qualifications of medical informatics personnel;

499   and 4) CHIMA, CHIA, and SCMI should align their organizational efforts with international MI

500   research fields and extant needs to develop medical informatics in China.

501   A special note is that, even though conference analysis has offered interesting insights on

502   the current status of MI in China and the U.S., better measures such as publications and grants

503   will be explored in our next studies. In addition, our current analysis focuses on the development

504   of Medical Informatics in China and comparison to part of that in the United States of America.

505   Our next research plan to include data from Medical Informatics Europe Conferences (MIE) and

506   World Congress on Medical and Health Informatics (MEDINFO), so that the present study can

507   be further extended to the status quo analysis and comparison of China and the European and

508   world medical informatics development.

509   Because of the space limitations of this paper, readers may refer to Appendix A-4 (*Several*

510   *Suggestions for the Development of Medical Informatics Discipline with Chinese*

511   *Characteristics*), if more information is desired.

512

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614   **TABLES**

615   **Table 1.** Basic information on the CMIAAS, CHINC, CHITEC, and CPMI conferences.

616   CMIAAS, only 12 conferences have been held since 1981-2015; CPMI, 24 conferences have

617   been held since 1993-2016; CHITEC, only 13 conferences have been held since 2004-2016;

618   CHINC, 20 conferences have been held since 1997-2016.

619

620   **Table 2.** Summary of the CMIAAS, 2015; CHINC, 2015; CHITEC, 2015; CPMI, 2015; AMIA,

621   2015; and HIMSS, 2015 conferences.

622

624 **FIGURES**

625

626 **Figure 1.** Conference proceedings of the CMIAAS (2008-2015), CHINC (2008, 2012, 2014,

627 2015), CHITEC (2008, 2011, 2013-2015), and CPMI (2008-2012, 2014, 2015).

628

629 **Figure 2.** The number of CMIAAS (2008-2015), CHINC (2008-2016), CHITEC (2008-2016),

630 and CPMI (2008-2016) conference attendees.

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632 **Figure 3.** Author affiliations at four mainstream Chinese medical informatics conferences

633 (CMIAAS, CHINC, CHITEC, and CPMI).

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635 **Figure 4.** Geographic distribution of authors among the CMIAAS, CHINC, CHITEC, and CPMI

636 conferences (the top three provinces and/or municipalities are listed).

637

638 **Figure 5.** Distribution of topics among the CMIAAS, CHINC, CHITEC, and CPMI conference

639 proceedings.

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641 **Figure 6.** Comparison of major characteristics of MI conferences (academic) in the U.S. and

642 China, 2015.

643

644 **Figure 7.** Comparison of major characteristics of MI conferences (industry) in the U.S. and

645 China, 2015.

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Basic information on the CMIAAS, CHINC, CHITEC, and CPMI conferences.

CMIAAS, only 12 conferences have been held since 1981-2015; CPMI, 24 conferences have been held since 1993-2016; CHITEC, only 13 conferences have been held since 2004-2016; CHINC, 20 conferences have been held since 1997-2016.

	Organizer	Inception	Schedule	Number of Conferences Held	Conference Duration	Type	Scale of Last Conference (number of attendees)
CMIAAS	China Medical Informatics Association	1981	Every 3 years	12	1 day	Academic conference	200+ (CMIAAS 2015)
CPMI	Medical Informatics Branch, Chinese Medical Association	1993	Annual	24	1 day	Academic conference	500+ (CPMI 2016)
CHITEC	China Institutes of Health Information	2004	Annual	13	2 days	Industry conference	5000+ (CHITEC 2016)
CHINC	Committee on Information Management, Chinese Hospital Association	1997	Annual	20	3 days	Industry conference	3500+ (CHINC 2016)

2 **Table 1.** Basic information on the CMIAAS, CHINC, CHITEC, and CPMI conferences. CMIAAS, only 12 conferences have been

3 held since 1981-2015; CPMI, 24 conferences have been held since 1993-2016; CHITEC, only 13 conferences have been held since

4 2004-2016; CHINC, 20 conferences have been held since 1997-2016.

Summary of the CMIAAS, 2015; CHINC, 2015; CHITEC, 2015; CPMI, 2015; AMIA, 2015; and HIMSS, 2015 conferences.

Conference Name	Organizer	Inception	Schedule	Meeting Duration	Number of Attendees	Composition of Attendees	Academic Achievement	Paper Review Mechanism	Number of Participating Companies	Fields Covered
CMIAAS 2015	China Medical Informatics Association	1981	Every 3 years	1 day	200+	Medical institutions, universities, research institutes	Four forums, 71 conference papers	Format review only	5	B, D, I, F, P, T
CPMI 2015	Medical Informatics Branch, Chinese Medical Association	1993	Annual	1 day	300+	Medical institutions, research institutes, universities	Four forums, 248 conference papers, including 13 papers presented at the general conference and 48 papers at forums	Format review only	13	L, D, B, F, P
AMIA 2015 annual symposium	American Medical Informatics Association	1977	Annual	4 days	2300 +	Medical institutions, universities, research institutions, companies	Ten forums, 14 continuing education classes, and 114 lectures; 156 full-text papers, 80 abstracts, 36 exchange articles, 1109	Rigorous peer review mechanism	50	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T

						posters, 12 system presentations, 7 contests of student-led project design.			
AMIA 2015 joint summits		2008	Annual	4 days	1400+		Sixteen forums, 6 continuing education classes, 136 lectures; 66 full-text papers, 158 posters		15	
CHITEC 2015	China Institutes of Health Information	2004	Annual	2 days	3300+	Medical institutions, research institutes, government authorities, enterprises, some universities	Ten forums, 87 continuing education lectures; 667 conference papers, of which 37 were nominated as "outstanding papers"	Format review only	100+	M, N, K, C, D, I, F, H, Q, T

| CHINC 2015 | Committee on Information Management, Chinese Hospital Association | 1997 | Annual | 3 days | 3500 | Medical institutions, enterprises, some universities and research institutes | Seven forums, 99 continuing education lectures; 853 conference papers, of which 71 were nominated as "outstanding papers" | Format review only | 150+ | B, D, I, F, P, T |
| HIMSS 2015 | Healthcare Information and Management Systems Society of the US | 1962 | Annual | 4 days | 38,000+ | Companies, medical institutions, research institutions | More than 250 forums and presentations, more than 300 continuing education lectures, one-day pre-conference seminar | Presenters required to submit abstracts and PPT for peer review | 1200+, with review performed between 12 regions | L, D, B, F, P |

2   **Table 2.** Summary of the CMIAAS, 2015; CHINC, 2015; CHITEC, 2015; CPMI, 2015; AMIA, 2015; and HIMSS, 2015 conferences.

3   Notes:

4   **A**: consumer health informatics; **B**: clinical information management; **C**: decision support system; **D**: electronic medical records; **E**:
5   medical language processing; **F**: nursing informatics; **G**: achievement evaluation; **H**: public health informatics: **I**: information
6   retrieval; **J**: medical cognitive science; **K**: clinical project management; **L**: computer-based training; **M**: coding, classification and

7   terminology; **N**: clinical guidelines for computerization; **O**: image, robotics, virtual medical treatment; **P**: signal processing; **Q**:

8   standards, social and legal issues; **R**: dental informatics; **S**: artificial intelligence; **T**: telemedicine.

Figure 1

Conference proceedings of the CMIAAS (2008-2015), CHINC (2008, 2012, 2014, 2015), CHITEC (2008, 2011, 2013-2015), and CPMI (2008-2012, 2014, 2015).
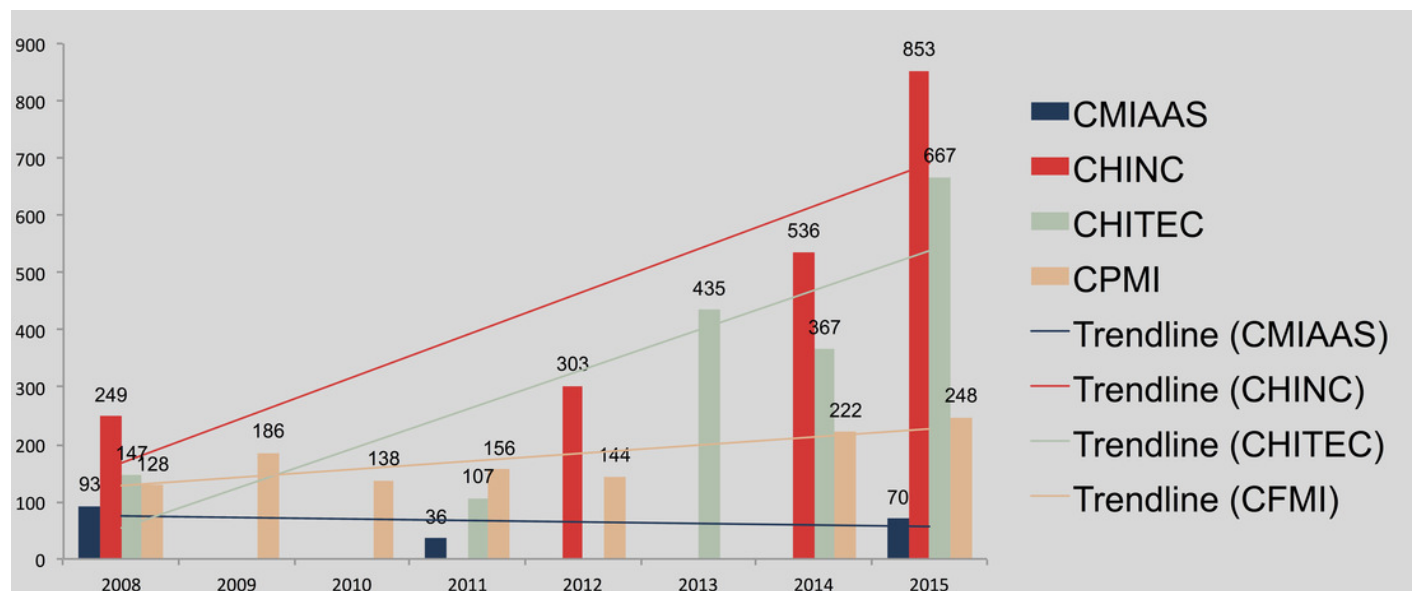
Figure 2

The number of CMIAAS (2008-2015), CHINC (2008-2016), CHITEC (2008-2016), and CPMI (2008-2016) conference attendees.
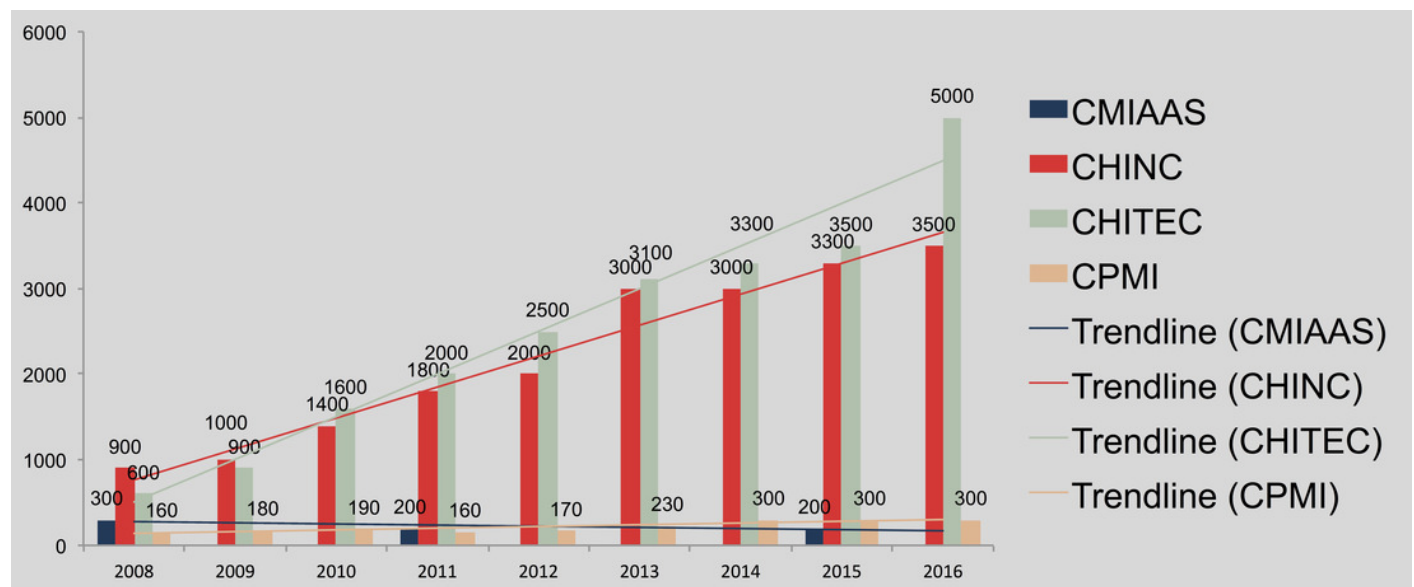
Figure 3

Author affiliations at four mainstream Chinese medical informatics conferences
(CMIAAS, CHINC, CHITEC, and CPMI).
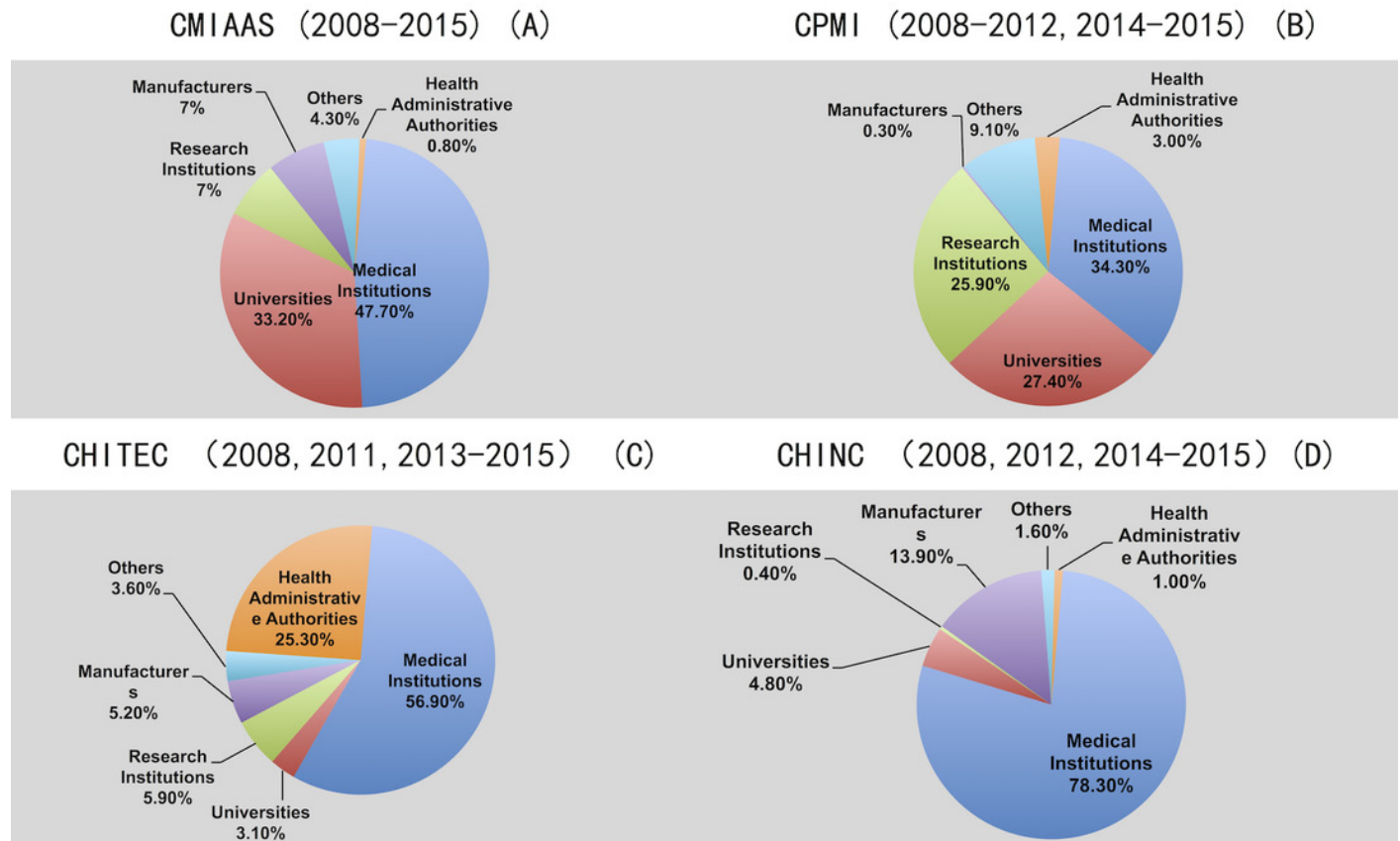
Figure 4

Geographic distribution of authors among the CMIAAS, CHINC, CHITEC, and CPMI conferences (the top three provinces and/or municipalities are listed).
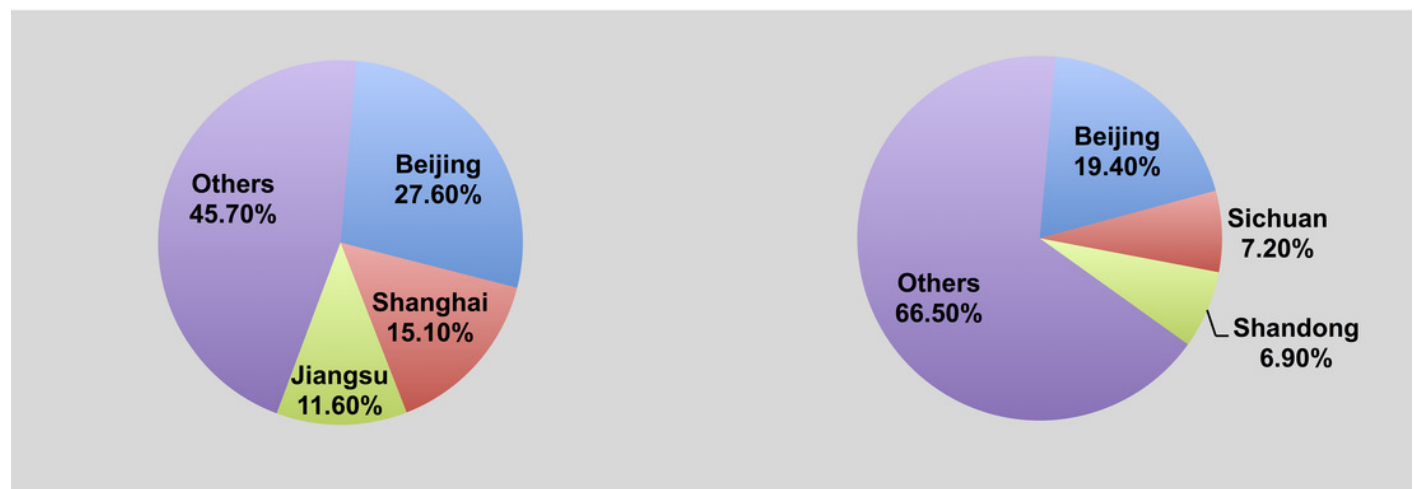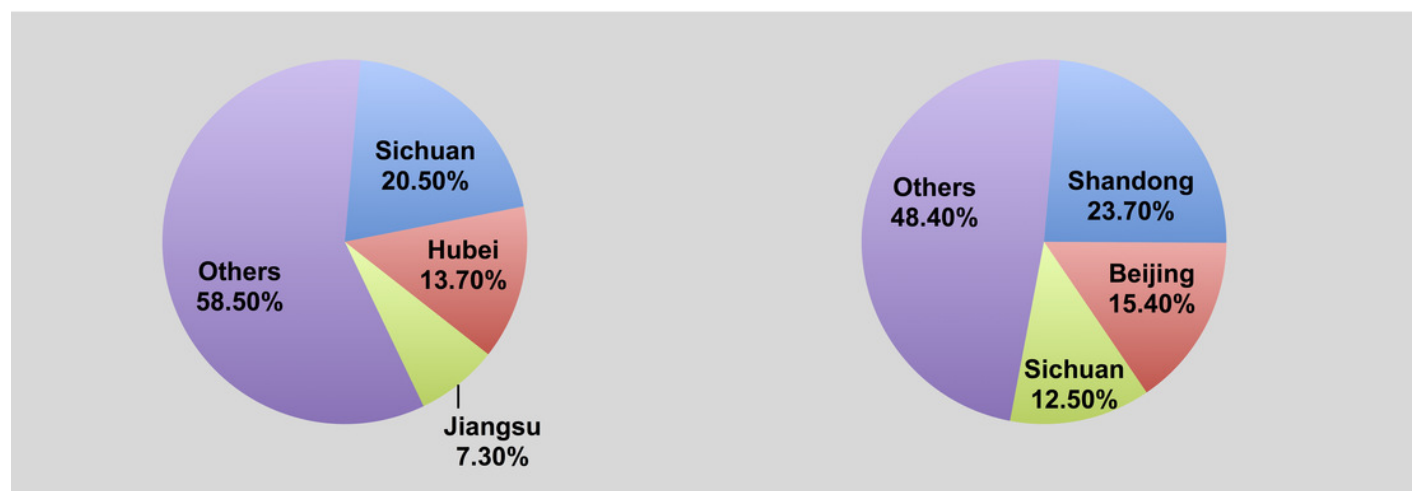
Figure 5

Distribution of topics among the CMIAAS, CHINC, CHITEC, and CPMI conference proceedings.
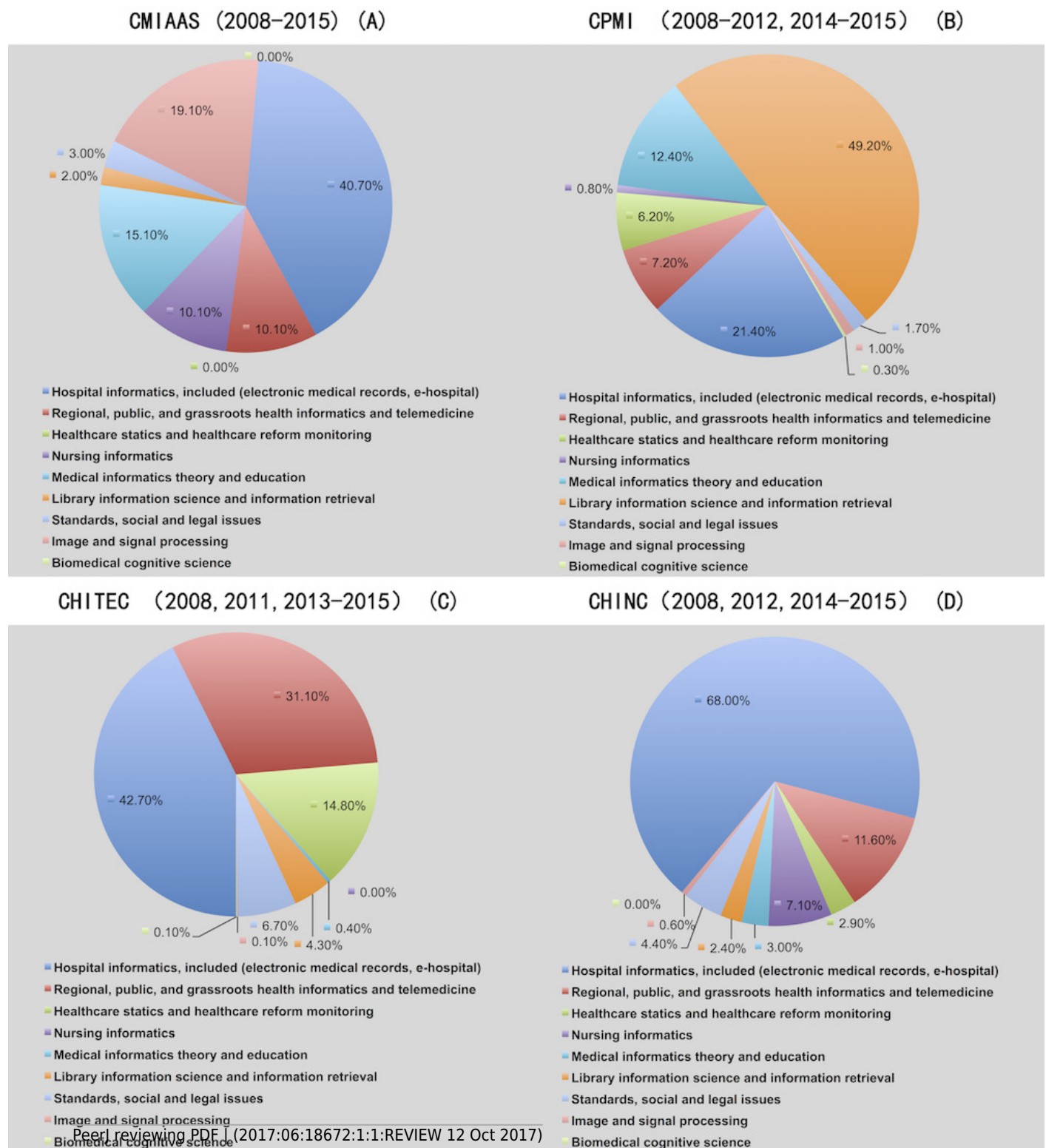
Figure 6

Comparison of major characteristics of MI conferences (academic) in the U.S. and China, 2015.

Figure 7

Comparison of major characteristics of MI conferences (industry) in the U.S. and China, 2015.