Ekoloji 28(107): 311-316 (2019)

Evaluation Model for the Application of Artificial Intelligence Medical Assistant System to the Development of Medical Ecology in China

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Abstract

People are increasing the requirements for medical ecology in past years so that the establishment of an electronic medical care mechanism becomes urgent. Along with the development of network technology and the advance of information technology, electronic data could be done the statistical analysis. By extracting electronic medical records through the Internet, physicians could rapidly grasp complete medical record information for the diagnosis to further enhance medical quality and assist hospital managers in making proper decisions. Aiming at upper first-class hospitals in Shanghai, total 12 representative hospitals with artificial intelligence medical assistant systems are selected as the research objects for this study. Based on the annual statistical reports of the hospitals, "Delphi Method" and "Data Envelopment Analysis" are utilized for the data analyses. The research results are summarized as followings. 1. One DMU presents strong efficiency on the artificial intelligence medical assistant system performance, 4 DMUs show the efficiency in 0.9-1, and 5 DMUs appear the efficiency lower than 0.9. 2. Sensitivity analysis is utilized for analyzing and finding out the critical factors in the application of artificial intelligence medical assistant systems to medical ecology, and the inputs and outputs are gradually removed for DEA to understand the sensitivity to efficiency. According to the results, suggestions are proposed, expecting to provide medical ecology with the application of artificial intelligence medical assistant systems extracting data through diagnosis systems to perfect the medical record information of patients for physicians' diagnoses and to further promote medical quality.

Keywords: medical ecology, artificial intelligence, medical assistant system, performance evaluation

Shieh C-J, Wan G-S, Wang W, Luo Y (2019) Evaluation Model for the Application of Artificial Intelligence Medical Assistant System to the Development of Medical Ecology in China. Ekoloji 28(107): 311-316.

INTRODUCTION

Along with increasing national income in past years, people present higher requirements for medical ecology. To cope with huge outpatient visits and balance the diagnosis quality, it is urgent to establish an electronic medical care mechanism. Furthermore, medical records are mostly handwritten in traditional medical ecology that a lot of time and manpower would be spent on seeking medical records and retrieving examination data and diagnosis records. In such medical ecology, the records would easily become illegible and time-consuming to seek and would become difficult to cope with increasing outpatient visits. With electronic medical records and data transmission through networks, the efficiency and medical quality would be enhanced. For this reason, it becomes inevitable to promote electronic medical records in order to cope with the huge medical ecology and reinforce the medical quality. Along with the development of network technology and the advance of information technology, the demands of medical institutions for exchanging data through networks are increasing. The development of electronic medical records therefore would assist in the rapid access of data to enhance efficiency and reduce communication costs for medical ecology. In addition to better data storage and access than paper-based records, electronic medical records could display different data according to the role of medical staff and different requirements, instead of placing different data in various places as for paper-based records. Moreover, electronic medical records are more legible than paper-based records to reduce

 Received: 22 Jul 2017 / Accepted: 19 Nov 2018

mistakes. Electronic medical records could accelerate physicians' retrieval of medical records, enhance service quality, and reduce manpower and space for medical records. More importantly, electronic data could be done statistical analyses at any time, and the acquisition of electronic medical records through the Internet allows physicians rapidly grasping complete medical record information to assist the diagnoses, further promote medical ecology, and assist hospital managers in making proper decisions. Without data exchange standards, the exchange complexity would be enhanced. It is therefore essential to make information exchange standards for medical ecology. Current information exchange standards in medical ecology are based on those in European and American countries, and the standards are adopted by various countries in the world. The purpose is to provide the information exchange standard in medical ecology among different applications to reduce custom system interface protocols and facilitate the circulation of information in medical ecology. Accordingly, efficient electronic diagnosis mechanisms and friendly user interface are essential to improve current diagnosis and treatment. Aiming at the performance evaluation for the application of artificial intelligence medical assistant system in medical ecology, experiments are preceded in this study, expecting to provide medical ecology with artificial intelligence medical assistant systems for perfecting patients' medical record information through the data extraction from medical ecology systems so as to assist physicians in the diagnoses and further promote medical ecology.

LITERATURE REVIEW

Artificial Intelligence

Liu et al. (2017) defined artificial intelligence as the study on having computers do better work than humans. Khosrow-Khavar et al. (2017) simply defined artificial intelligence as the study on having computers present smart characteristics. Gu et al. (2017) considered that artificial intelligence attempted to constantly give machines with human wisdom to simulate or replace human wisdom. In this case, artificial intelligence would be the mechanization or materialization of human wisdom and further extend to the effect intensity and function coverage of human wisdom so that computers could think, judge, learn, and solve problems as human brains. Shafiq et al. (2016) regarded artificial intelligence as the technology to make things smarter that it could be defined as having machines present human wisdom. Duport Dejonckheere et al. (2016) regarded it as a general term to have computers executing human work; the coverage of artificial intelligence was distinct and would present more applications and changes with time. Sahoo et al. (2018) pointed out current systems as weak artificial intelligence that a system could do one or more things with the same or even higher degree as humans. For instance, learning systems were created through programming to identify objects or gestures. Natural language process, artificial intelligence in electronic games, and machine learning were weak artificial intelligence.

Medical Assistant System

Yang et al. (2017) stated that medical assistant programs were developed and broadly applied in past few years, which could be tracked from desktop personal computers to distributed database systems. De Forgeet al. (2017) regarded medical assistant programs as commissioned programs, which were broadly applied to various information processing and management due to the characteristics of individualization, constant execution, and semi-autonomy. Bruun et al. (2018) pointed out the following characteristics required for a medical assistant program. (1) Personification: A well-designed assistant program had to perform the same behavior as humans to communicate and interact with humans. (2) Persistence: An assistant program should be a constantly executing program, rather than stopping the execution after outputting a response to an input. (3) Autonomy: An assistant program could independently execute some work according to certain situations and conditions. When necessary, it could continuously execute certain specific tasks. (4) Communication skills: An assistant program should be able to communicate with other assistant programs and users in order to acquire information and explain the achievement of tasks (Kalarthi 2016). (5) Adaptability: An assistant program could change itself by recording past interaction experience with users to adapt to user preference (Sadoughi et al. 2016). Besides, an assistant program could change itself with different environment. (6) Mobility: An assistant program was able to shuttle back and forth various types of systems, machines, and platforms for extracting information (Mohan and Raja 2016). Hussian et al. (2017) regarded the target oriented design of medical assistant program that simply instructing an assistant program with a "target", through built-in rules and intelligence, the assistant program could complete the task without instructions of time and methods.

According to single or multiple medical assistant program systems and the communication and

application with other medical assistant programs, Cho et al. (2016) classified assistant programs into

(1) Regional assistant program: Such a type of assistant programs merely assisted users in dealing with some routine work.

(2) Network assistant program: With better intelligence than regional assistant programs, it presented smart network interface and could provide network service (e.g. extracting data through the Internet). However, such a type of assistant programs could not communicate with other assistant programs.

(3) Distributed artificial intelligence assistant program: Distributed artificial intelligence could use intelligent software modules on various nodes in a distributed system and solve problems with cooperative intelligent attitudes (Roy et al. 2016). Such a type showed common communication mechanisms and aimed to communicate with other assistant programs.

(4) Mobile assistant program: It could work in various workstations on the network and was stored in a larger and complicated system so that it could provide more complicated services (Santhi and Gayathri 2016).

The medical assistant system mentioned in this study could work in various workstations on the network and operate complicated system environment with artificial intelligence.

RESEARCH INDICATOR AND OBJECT

Establishment of Research Indicator

From above performance evaluation indicators for applying artificial intelligence medical assistant systems in medical ecology, Delphi Method is utilized in this study to draw the performance evaluation indicators for the artificial intelligence medical assistant system. Delphi Method, also named expert judgment, is a group decision-making method with both qualitative and quantitative characteristics as well as interdisciplinary and future oriented. Some issues with inadequate data or unknown situations could acquire a commonly acceptable answer through anonymous questionnaire survey of experts for several runs of votes and feedback to reduce different opinions.

The so-called "experts", according to the suggestions in literatures, should present the following conditions (Delbari et al. 2016). (1) Showing the interest in participating in the Delphi Method survey. (2) Presenting rich information for sharing. (3) The knowledge and techniques in specific fields are approved. (4) Presenting specialties on the surveyed topic, including practical experience and theoretical research. (5) Agreeing with the research result containing the special information owned. Mishra & Chatterjee (2018) also indicated that experts should present knowledge level, reliability, and accuracy and show deeper understanding of the industry than amateurs so that the judgment was closer to the fact than it of ordinary people. The value of Delphi Method was built upon such answers.

Establishment of Evaluation Indicator

With Delphi Method to establish the evaluation indicators, the variables are defined as below.

Input variable

1. Finance: including costs for establishing artificial intelligence medical assistant system and personnel cost.
2. System level: Level of system communication.

Output variable

1. Customer: Average medical time for a patient.
2. Scale: Patients' data size in the data base.

Research Method and Object

In terms of research object, upper first-class hospitals in Shanghai, with artificial intelligence medical assistant systems, are selected. According to the annually statistical reports as the input and output performance to select indicators, "Delphi Method" and "Data Envelopment Analysis" are utilized for data analyses to provide improvement reference. Total 12 DMUs are selected in this study.

Efficiency Evaluation Analysis

Different from traditional regression analysis which merely searches for the mean path of a series of data, Data Envelopment Analysis (DEA) envelops various sample data and attempts to find out the relationship. It presents the advantage requires for good efficiency evaluation models that it is used in this study for evaluating efficiency. The method applies linear programming, takes the factors in the measurement of performance among DMUs into account, and compares the performance of units with similar characters.

Table 1. Relative efficiency of hospitals

hospitals in Shanghai	overall efficiency	technical efficiency	scale efficiency
Children's Hospital of Shanghai	0.88	0.87	0.89
Shanghai CHangzheng Hospital	0.95	0.94	0.95
Zhongshan Hospital	0.93	0.92	0.93
Xinhua Hospital	0.75	0.75	0.75
Longhua Hospital	0.87	0.86	0.87
Renji Hospital	1.00	1.00	1.00
SShanghai Shuguang Hospital	0.82	0.82	0.81
Shanghai General Hospital	0.98	0.98	0.99
Shanghai Sixth People's Hospital	0.84	0.83	0.84
Huashan Hospital	0.97	0.97	0.97
CHanghai Hospital	0.78	0.77	0.78
Huadong Hospital	0.80	0.81	0.80

EMPIRICAL ANALYSIS OF THE PERFORMANCE EVALUATION OF ARTIFICIAL INTELLIGENCE MEDICAL ASSISTANT SYSTEM

Performance Evaluation Analysis of Artificial Intelligence Medical Assistant System

By substituting input/output indicators into CCR and BCC models, the overall production efficiency and pure technical efficiency of hospitals could be calculated. Such two values are further divided to acquire the returns to scale of hospitals. The overall production efficiency, pure technical efficiency, and scale efficiency are organized in **Table 1**.

From **Table 1**, Renji Hospital, with the overall production efficiency=1, is relatively efficient, while the rest hospitals appear low overall production efficiency; especially, Xinhua Hospital, with the lowest overall efficiency, is relatively the most inefficient hospital. In other words, except 1 DMU with the overall production efficiency=1, the rest 11 DMUs are relatively inefficient. The reason for the inefficiency might be not being able to effectively apply inputs or not achieving the optimal production scale. It requires further analyses.

Sensitivity Analysis

Sensitivity analysis is used for the risk evaluation in this study to analyze and find out the key factors in the application of artificial intelligence medical assistant systems in medical ecology. Various inputs and outputs are gradually removed for DEA to understand the sensitivity to efficiency. The research results are based on sensitivity changes, and the sensitivity factors contain finance, system level, customer, and scale. From **Table 2**,

Table 2. Sensitivity analysis of gradual removal of inputs and outputs

DMU	original relative efficiency	removing finance	removing system level	removing customer	removing scale
Children's Hospital of Shanghai	0.88	0.80	0.81	0.83	0.84
Shanghai CHangzheng Hospital	0.95	0.88	0.89	0.90	0.91
Zhongshan Hospital	0.93	0.86	0.85	0.90	0.88
Xinhua Hospital	0.75	0.67	0.66	0.70	0.71
Longhua Hospital	0.87	0.80	0.81	0.83	0.84
Renji Hospital	1.00	0.90	0.88	0.92	0.93
SShanghai Shuguang Hospital	0.82	0.75	0.77	0.78	0.80
Shanghai General Hospital	0.98	0.92	0.91	0.94	0.95
Shanghai Sixth People's Hospital	0.84	0.76	0.78	0.80	0.81
Huashan Hospital	0.97	0.91	0.90	0.92	0.93
CHanghai Hospital	0.78	0.71	0.73	0.75	0.75
Huadong Hospital	0.80	0.73	0.72	0.74	0.75
number of efficient DMU	1	0	0	0	0

Data source: self-organized in this study

(1) All DMUs reduce the efficiency after removing "finance" that finance reveals higher importance to all DMUs.

(2) All DMUs reduce the efficiency after removing "system level" that system level appears higher importance to all DMUs.

(3) All DMUs reduce the efficiency after removing "customer", showing higher importance of customer to all DMUs.

(4) All DMUs reduce the efficiency after removing "scale", revealing higher importance of scale to all DMUs.

CONCLUSION

According to the efficiency from DEA and various variables, 1 DMU, about 8% of all DMUs, presents strong efficiency on the artificial intelligence medical assistant system performance, with the efficiency=1, revealing the better execution efficiency of the artificial intelligence medical assistant system; 4 DMUs, about 33% of all DMUs, show marginal inefficiency on the artificial intelligence medical assistant system execution, with the efficiency in 0.9-1, that the execution efficiency

could be more easily enhanced; 5 DMUs, about 58% of all DMUs, are obviously inefficient on the artificial intelligence assistant system performance, with the efficiency lower than 0.9, among which Xinhua Hospital appears the lowest efficiency on the artificial intelligence medical assistant system performance.

The cluster development of artificial intelligence industry is promoted in Shanghai in past years, with persistence on artificial intelligence equipment, product and core components, collaborative development of systems, actively cultivating artificial intelligence emerging industries focusing on intelligent driving, intelligent robots, and intelligent hardware, as well as stressing on enhancing core capabilities of industry with intelligent sensors, intelligent chips, and intelligent software. In face of the opportunity resulted from digital transformation, Renji Hospital affiliated to Shanghai Jiaotong University applies the artificial intelligence medical assistant system to simulate "doctors", according to ruled questions, calling patients to track the treatment of patients, including the situations of vomit, pain, fever, and wound infection. The application of AI largely enhances the tracking and treatment efficiency and ensures the coverage and accuracy of tracking and treatment information collection. It reduces heavy tracking and treatment work for medical staff and could make individualized tracking and treatment programs according to patients' records, automatically call patients and communicate with patients, effectively collect patients' answers, and transform such voice answers into text records. After completing the tracking and treatment, the medical staff could clearly understand each patient's situations on the system. It is understood that the artificial intelligence medical assistant system could continuously track the treatment of 400-1000 patients to largely enhance the tracking and treatment efficiency. Moreover, the artificial intelligence medical assistant system would precede statistical analyses of collected patient information to provide effective data support for clinical and scientific research work.

SUGGESTION

Aiming at the application of artificial intelligence medical assistant system in medical ecology, the following suggestions are proposed in this study.

1. Information in medical ecology is sensitive data and involves in personal privacy that it could not be accessed without authority. The medical assistant system exchanges data through the Internet that the network security is primary. Furthermore, physicians are responsible for patients' medical records to avoid medical malpractice claims. In this case, it is suggested that digital signature and data encryption could be combined for the functions of authentication, data confidentiality, data integrity, and non-repudiation of data.

2. Since physicians are busy, the multimedia user interface of the artificial intelligence medical assistant system provides monitoring function so that physicians could understand patients' conditions on the computers and judge the necessity for further operation to reduce the work burden. Image acquisition equipment therefore could be installed in wards to constantly record patients' state and save in the server. Physicians could observe the patients' conditions through the medical assistant system interface to understand the situation and give further instructions to nurses. It would reduce physicians' workload and provide better care for patients to largely promote medical quality.

3. The rapid development of wireless transmission technology allows artificial intelligence medical assistant systems being compatible with various mobile devices. As different medical ecology appear various system platforms to result in technical problems. To overcome such difficulties, a mobile diagnosis assistant is practicable. Besides, artificial intelligence technology could be applied to the automation of medical ecology systems and provide users with more service and convenience.

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