

EXPLORING CRUCIAL FACTORS FOR INTEGRATING MEDICAL CLOUD AND HEALTHCARE LOGISTICS BY DANP

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ABSTRACT

This study aims to investigate and explore the critical success factors which affect the integration of medical cloud and pharmaceutical logistics operations. To achieve research objective, we firstly collected the opinions of medical management experts through the process of the Delphi method, and then affecting the integration of medical cloud and healthcare logistics operations were screened and summarized. Secondly, the questionnaire was conducted and 11 experts' assessments of the influence between every two factors were acquired. Furthermore, this study employed DANP to calculate the weight for each factor when there exists interaction relationship among the factors and to plot causal map. Reviewing the causal map and the weights for each factor, "To induct artificial intelligence (AI) into medical treatment" and "To develop intelligent healthcare logistics" are significantly higher than other factors in terms of total influence value, net influence value and relative importance. Our findings can provide hospitals and pharmaceutical companies as a basis in formulating cloud medical development strategy.

Keywords: Medical Cloud; Healthcare Logistics; Crucial Factors; DANP.

1. INTRODUCTION

As the people's needs on material culture are getting higher and higher, they are also paying more attention to their health. More and more hospitals at home and abroad are seeking solutions to reduce medical costs, increase the flexibility of the pharmaceutical supply chain, and strengthen the hospital's service level to cope with increasing efficiency requirements. There are minimal studies on cloud medical and pharmaceutical distribution at home and aboard, including very few integrated applications for cloud medical and pharmaceutical distribution. Under such a social background, we should emphasize their importance.

Currently, some hospitals have started to use the integrated cloud medical and distribution, but they have failed to produce good results due to many problems hidden within. There is a lack of studies in this area, and there are very few hospitals using this concept, not to mention the little flexibility of the pharmaceutical supply chain as well as the entire supply chain. The reasons are inadequate information sharing among pharmaceutical material suppliers, drug suppliers, hospitals, and consumers. The slow drug distribution from the hospitals has thus resulted in low customer satisfaction. So, this paper aims to integrate the definition and connotation, types, measurement research, and other means of elaboration on cloud medical and pharmaceutical distribution. The undertakings are integrating cloud medical and pharmaceutical distribution properly, making a systematic plan to deal with diversified consumer needs brought about by economic globalization and sustainable development.

The paper is divided into five parts to analyze and evaluate the integration of cloud medical and pharmaceutical distribution. The hospitals at Fuzhou were chosen as examples for an explanation. Part 1 will elaborate on the research background, research purposes, significance, and clarification of the scope and research limitations. Part 2 will review the relevant literature on pharmaceutical distribution, cloud medical, and decision-making experimental analysis methods. Part 3 will introduce the DEMATEL-based Analytic Network Process (DANP) algorithm. Part 4 will introduce and analyze the current status of SPD and medical logistics in Fuzhou regional hospitals, construct the factors and structural aspects that affect the integration of cloud medical and pharmaceutical logistics, get the expert's assessment, and perform the final DANP analysis. Part 5 will thoroughly combine the measurement and evaluation results, and propose feasible suggestions for integrating cloud medical and pharmaceutical distribution to make them more realistic.

2. LITERATURE REVIEW

2.1. Pharmaceutical Supply, Processing, and Distribution (SPD)

American scholars originally proposed the concept of SPD. Although this concept was first put forward in the United States, many hospitals in Japan began to implement this system shortly after the proposal. Now China is also actively supporting and encouraging to implement SPD, where many hospitals have made small achievements in this regard.

The management models of the SPD procurement supply chain refer to the comprehensive statistics of the hospital's upper-level suppliers, the hospital's required drug facilities, communication with the hospital through modern information channels, and concentrating the procurement of drugs from the suppliers. At the same time, the suppliers should provide the hospital with full logistics management, such as inventory management, customized drug packaging in separated or combination forms [12].

The implementation of the SPD model in hospitals can strengthen the supervision and circulation of drugs, reduce the costs of medical care, and improve the social and economic effects of hospitals, thereby paving the way for them in future development. It is necessary to strengthen the construction of information technology to improve SPD efficiency. Now that modern society has become a changeable society; any system has to be integrated with reality. Only then can we realize the modern logistics [13].

2.2. Cloud Medical

1) The meaning of cloud medical

Cloud medical is a new type of medical service. It is the combination of high-tech technologies, such as the Internet, the Internet of Things (IoT), and big data with medical services to promote fast hospital operation. Such a new operating concept and pleasant customer experience will enhance the hospital's comprehensive strength and competitiveness [2].

Gao Feng, Mao Dian, and Wang Sheng have defined cloud medical as the use of network interaction methods to integrate all hospital processes (including appointments, doctor

consultation, dispensing the drugs to customers, etc.) through a network platform to increase customer satisfaction. The concept of applying a cloud medical concept can improve the hospital's previous inherent problems and save time, thereby reducing the registration time, queueing, and payment significantly. Cloud medical is a new medical model and a new service model, and the effect of using this model is evident [11].

2) Significance and advantages to realize cloud medical

First of all, there are many small-scale hospitals where fewer people would like to go. Even if the hospitals have used the cloud medical management system, they still cannot change their inherent problems. So, having a standardized medical system is the core to attract patients to visit. The cloud medical-based management system can make full use of its advantages and achieve the best results. Cloud medical can only play its roles well if supported by a large number of patients, helping all service data links in the hospital and clinic to communicate with each other and work out the procedures effectively.

Secondly, the cloud has one of the most critical advantages of reasonable cost control. The cloud belongs to the hospital information organization and needs more funds when it is initially implemented. A continuous rise in the economic level will increase people's needs and harder to satisfy their demands. After a while, when the people's demand preferences have changed, the system will subsequently be altered.

Listed below are some of the highlights of cloud medical:

- Time-saving. The use of a cloud medical platform will enable the doctors to view the patients' status on the network. If the patients do not have any significant problems, they can skip going to the hospital and save time. They can also use some network reservation platforms to shorten their waiting time, allowing them to schedule their appointments with the doctors orderly.
 - Wide coverage. The global interoperability of the Internet has expanded the coverage of the cloud medical platform.
- 3) Although cloud medical is meant to serve the people, it is also convenient for the hospitals for not having to establish specialized medical technology in them. Therefore, investment in medical technology is significantly small. The corresponding costs are not as high as we think.
- Cloud medical acceptability

As far as China is concerned, the concept of cloud medical is generally accepted by residents in the first-tier and second-tier cities where the city lives are faster, the economic development is quicker, and the scientific technology level is higher. Not only do young people have a deeper understanding of scientific technology, but many older people can also keep track of their lives. Their thinking is relatively open, and their acceptability is stronger, so their degree of acceptance on cloud medical is naturally higher. However, for some second-tier and third-tier cities, their acceptability is far less than that of the first-tier cities with a higher level of economic development. In underdeveloped cities, not only are the elderly conservative, but many young people also cannot keep up with the pace of the times, and it is hard for them to accept and apply new things that promote development. The so-called cloud medical in many cities is confined to online outpatient appointments.

2.3. Intelligent Pharmaceutical Logistics

The so-called pharmaceutical logistics means that the resources of the entire supply chain are effectively integrated under the support of some information systems related to logistics, and technologies related to logistics. The optimization of various pharmaceutical distribution processes can accelerate the hospital's order processing capability, enhance its efficiency, and improve customer satisfaction. Once the customer satisfaction has increased, it will subsequently improve the number of orders and reduce costs. Yang Wan-hong, Jiang Wei, and Wu Shi-yu believe that in the logistics operation process, there is a very high requirement on the quality of drugs [14].

Dong Wen-chen pointed out that cold chain logistics includes the distribution of pharmaceutical logistics. In the distribution process, the medical supplies must be frozen to ensure that they will not deteriorate and affect the health of residents. The pharmaceutical logistics is deemed successful if only it is integrated with all aspects of distribution, i.e., combining the use of refrigeration technology such as freezers and tracking the entire process through the network information technology. The whole of the cold chain logistics process must be carried out in a low-temperature environment. Many prescribed drugs and non-prescribed drugs, such as traditional Chinese medicines, western medicines, and vitamins, are classified in the scope of pharmaceutical distribution, and naturally listed in the range of cold chain logistics. Basically, drugs need to be delivered in frozen form to maintain their activity. Once the temperature is too high, many drugs will deteriorate and lose their activeness [4].

Many problems still exist in China's pharmaceutical logistics. As pharmaceutical logistics belongs to a branch of cold chain logistics, many scholars have seen their issues through different angles and proposed countermeasures to solve them. For example, Ge Li-qing, Zhang Jing-chao, and Wu Yan-yun have studied the mode and method of China's pharmaceutical cold chain logistics services and proposed improvement suggestions [10] [6].

3. DEMATEL-BASED ANALYTIC NETWORK PROCESS(DANP)

Listed below is the DANP algorithm.

Step 1: Defining the criteria (impact factors) and establishing a hierarchical structure of aspects and guidelines

Step 2: Obtaining the expert's assessment on the impact of pairwise comparisons among the criteria

Step 3: Constructing the initial impact matrix

Step 4: Normalizing the initial impact matrix

Step 5: Exporting the total impact matrix

Step 6: Drawing a causal diagram of the aspects and criteria

Step 7: Processing the estimated values of aspect impact

Step 8: Constructing an unweighted supermatrix

Step 9: Constructing a weighted supermatrix

Step 10: Calculating the supermatrix limitations

4. CASE ANALYSIS OF FUZHOU REGIONAL HOSPITALS

Fuzhou General Hospital is regarded as a three-level hospital. After decades of development, it has been improved with advanced infrastructure and high medical skills, allocated with many excellent doctors, and has managed the information technology soundly. According to a survey, this study found that the SPD used by Fuzhou General Hospital has mostly remained on making outpatient appointments through the online platform. The application of SPD only occurs between the hospital and the pharmaceutical suppliers, and there is no pharmaceutical distribution between the hospital and patients. The patients can only line up to pick up the doctors' prescriptions at the dispensary.

Many hospitals in Fuzhou have attempted to establish a hospital order by making appointments through the online platform, but the practice is very insignificant. Many older people do not make appointments on the Internet. Even if the family members have helped them to make online appointments, they will not pick up the number at the hospital's terminal. Even if everyone has made the appointments, the queuing order is still chaotic. Many people will queue up before the doctors come, and the doctors will diagnose the patients first under the active request of the patients. They do not adopt the "invalid overdue number" system, thus resulting in chaotic diagnoses.

Once the patients visit the hospitals, the hospitals are designed to meet their needs. The hospitals must provide patients with the fastest, most convenient, most effective, and lowest cost services. Life needs innovation, and these words in the medical world will not be outdated. The hospitals must always find suitable systems and regulations, and supervise their executions and deepen the reforms. Nowadays, not only do the hospitals need to emphasize their medical strength, but they also stress cost reduction and improve the operational efficiency to meet with the trend of the times. The chaotic queuing and pharmaceutical distribution phenomena are still prevalent in many hospitals in Fuzhou. Currently, the pharmaceutical distribution practice is even done manually in a flow line manner, thus causing increasing loss and damage of drugs. It is for this reason that we must work harder and apply all available means to enhance the efficiency of SPD.

From the relevant literature, it is found that most hospitals have the apparent problems of backward infrastructure equipment, inflexible distribution supply chain, and low SPD efficiency. Based on the research and analysis on the integration of cloud medical and pharmaceutical distribution, four aspects were proposed by this study to analyze and discuss the operation management, urban traffic pressure, quality and level of the distribution services, and distribution service benefits of the cloud medical platform, and 18 criteria were subsequently summarized.

Table 1: The factors and their description

No.	Factor	Factor Description
F1	To induct artificial intelligence (AI) into medical treatment	Introducing AI applications from doctors' prescriptions, pharmacists' adjustments, hospitalizations, to patients' medications not only to ensure the safety and quality of patients but also to reduce the unnecessary medical costs of subsequent derivation.

F2	Improving operation ability of hospital information system	Reduce stagnant material, drug damage, operational cost and manage the inventory level accurately.
F3	Supply chain coordination	How to deal with the relationship between upstream and downstream enterprises in the supply chain, and coordinate the flexibility and leanness of the entire supply chain is the primary task of supply chain development.
F4	Public Cloud	Import the computing power and scalability of the Public Cloud and combine with an experienced operations team to ensure the stability and security of a healthy cloud.
F5	Integrated pharmaceutical logistics services	The introduction of RFID electronic tags to assist management will maximize the efficiency of smart hospitals, accurate inventory management system, and save hospital drug and medicine storage space. Then, the goal of maximizing the use of hospital resources is achieved.
F6	Authority management	Each user authorized to enter the enterprise calculator information management system shall have a unique user identity and be granted different management rights according to the job responsibilities.
F7	Import smart health system	To manage inventory of medicines and medical equipment more effectively.
F8	Storage equipment with high-end cold chain technology	Compliance with the PIC/S GMP certification standards for the storage and protection of non-contaminated drugs
F9	Integrating the operations of the pharmaceutical supply chain	Real-time monitoring the medical equipment shipped from the factory to hospitals and other medical facilities or channel terminals.
F10	To develop intelligent healthcare logistics	Optimize material flow interactions, streamline workflow processes, prevent theft and diversion
F11	Building a supply chain cloud platform	The current issue for the inefficiency of the supply chain is the lack of interoperability between the operating systems of different nodes. In the medical field, it is difficult for third-party logistics EMR systems to interface with HIS systems. The establishment of a supply chain cloud platform can provide solutions.
F12	Tracking drug in supply chain	Prevent theft, diversion, monitor drug storage environment, drug recall
F13	Drug authentication	Counterfeiting, Drug pedigree
F14	Tracking drug in clinical trial	Track dose trial and administration
F15	Sharing medical resources	Avoiding hardware re-establishment and sharing medical resources and personal medical information is the core value of the medical cloud.

A causal diagram was drawn after obtaining the expert evaluation and data processing results.

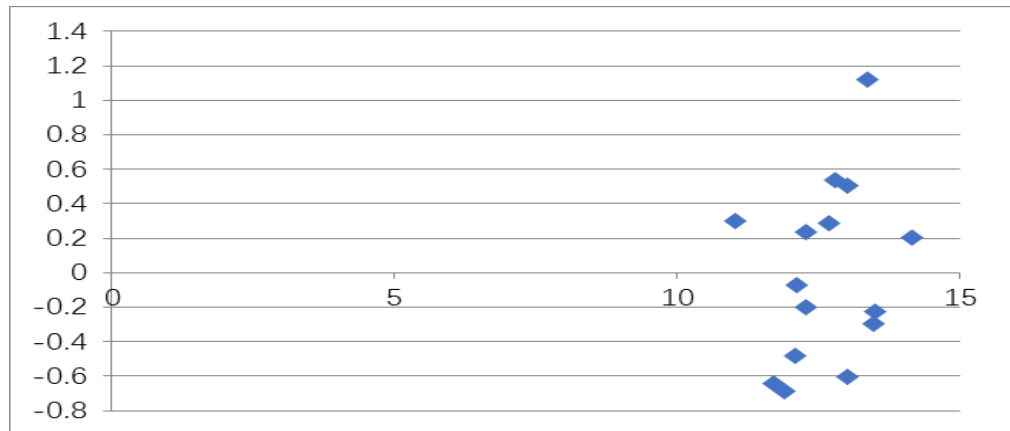


Figure 1: Causal map

The overall weight of the DANP was also obtained through the ANP algorithm.

From the causal diagram and the overall weight, the factors that have a more significant impact on cloud medical and pharmaceutical distribution, such as “information network technology,” and “different needs for drugs from various patients,” were selected among the factors affecting the planning of cloud medical and pharmaceutical distribution system. Regardless of the total impact, net impact, and overall weight, they are significantly higher than other factors. They are known as crucial factors.

5. CONCLUSION

In this paper, four significant aspects and 18 guidelines were summarized after collecting and analyzing the relevant data affecting the integration of cloud medical and pharmaceutical distribution. The analysis was further conducted on the causal relationship that affects cloud medical and pharmaceutical distribution, and the following conclusions were obtained:

First, the management level of the cloud medical platform is an essential factor affecting cloud medical and pharmaceutical distribution. The management level of the cloud medical platform includes platform maintenance, the management of relevant platform personnel, and the supervision of the platform operations.

Second, the practicality of the cloud medical platform. For one thing, there are uncertainties, or perhaps extremely high uncertainties, to achieve real diagnoses of patients through the network, and whether or not it can genuinely prescribe the right drugs for the patients according to their illnesses. This concept has not been adequately promoted in many hospitals in Fuzhou, as some hospitals have poor infrastructure and insufficient quality facilities. On the other hand, the elderly take up a large portion of patients, considering that the platform is a new thing that they do not know how to use. Both aspects are sufficient to illustrate the importance of the practicality of the cloud medical platform. So, the platform must be realistic and implementable before we can further discuss the efficiency issue.

Third, patient satisfaction with the services. As everything about the supply chain design and all logistics activities ultimately aims to improve customer satisfaction, it will increase the competitiveness of the hospital, and naturally, enhance its core competitiveness. More and more patients will then choose to visit this hospital, inquire about the diagnoses on the hospital's platform, and agree to its pharmaceutical distribution. This enterprise will eventually stand firm in this highly competitive globalized world.

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