The intelligent monitoring method for bidirectional referral information resource in hospital based on big data

Ying Cao

Jining First People's Hospital,
Shandong Jining 272002, China
Email: 43816568@qq.com

Can Cao*

Jining Medical University,
Shandong Jining 272113, China
Email: cancao@36haojie.com
*Corresponding author

Abstract: In order to overcome the problem that traditional hospital visits and referrals take a long time and the costs are not clear, this paper proposes an intelligent two-way referral information resource monitoring method based on big data. This method is based on the big data provided by the integration and application of intelligent two-way referral information resources in hospitals. Based on the theory of system engineering, the monitoring elements of two-way referral are constituted according to the subject, object and content of monitoring. The whole process of monitoring involves all aspects of referral. According to the sequence from admission to recovery, multiple monitoring points are defined, and monitoring contents are defined based on each monitoring point, and monitoring is carried out in a targeted way. The experimental results show that the method is effective, less medical expenses, short time to see a doctor, and feasible.

Keywords: big data; bidirectional referral; resource monitoring.

Biographical notes: Ying Cao is an undergraduate engineer from the Jining, Shandong, Qingdao Agricultural University, and currently in the Jining First People's Hospital. His main research direction is the application of electronic information in hospital management.

Can Cao completed his Master's degree and currently a Lecturer in the Jining, Shandong, Shandong Normal University. Her main research direction is computer network technology. She is currently in the Jining Medical University.

1   Introduction

After the introduction of the new medical reform, China's attention to community health services is increasing. Two-way referral is an important part of the reform of community health services, which has become the focus of the medical industry in China (Yu and Sun, 2017; Tomasic et al., 2018; Vearrier and Greenberg, 2017). A Bi-Directional Referral System "considers both the information going from the healthcare system to the referred community program or resource" (e.g., a CDC recognised lifestyle change program or a diabetes self-management education program) and the information returning from that program to the healthcare system. Ideally, the Bi-Directional Referral System will be integrated with an electronic health record (EHR) system and will facilitate electronic bi-directional feedback between the community program and the healthcare system (e-referral system). An e-referral system can provide baseline reports on the number of referrals, number of services received, and number of pounds lost and when integrated with the EHR, health systems can evaluate the impact of these community programs on population health. With this information community-based organisations can make the case for clinically meaningful and cost-effective 'programming' (Bi-Directional Referral System, https://www.chronicdisease.org/mpage/domain4_referral). Due to the problem of information island in the current two-way referral data, it is impossible to establish an effective information resource monitoring system, which leads to the lack of management system in the referral system of medical institutions (Pierce et al., 2017; Zini et al., 2017). At present, there are a lot of research results about two-way referral information resource monitoring methods.

Gao et al. (2017) investigate, monitored and discussed the willingness and influence of community residents on bidirectional referral. Through simple random sampling method, 40 community residents were randomly investigated in each community. In the form of questionnaire survey, the willingness of community residents to bidirectional referral was monitored and analysed. After the analysis of 298 valid questionnaires, the conclusion was as follows: it should design the bidirectional referral information resource platform and optimise the technology of community health service, so as to promote the overall implementation of the bidirectional referral and provide more suitable medical services for the public. This paper conducted a public opinion survey on the bidirectional referral hospital of community residents. The results of the survey were helpful to grasp the follow-up research direction, but no specific method research was involved. Chen et al. (2017) focused on monitoring and analysing the policies and operation status of grading medical care and bidirectional referral in Heilongjiang. It also proposed to re-plan the health service system of the whole province, optimise the allocation of health resources according to the new concept of big health, and improve the health of the internet with the help of internet plus health project, so as to provide reliable theoretical basis for the progress of the medical industry. However, the scheme was not easy to popularise, and the implementation cycle was long and the timeliness was poor. Shen et al. (2017) monitored and analysed the data of resource distribution and medical resource sharing and utilisation of medical institutions at all levels in Wuxi City. Combined with the investigation and interview of medical staff and patients, it was found out the current problems of hierarchical diagnosis and treatment and bidirectional referral in Wuxi City. Some suggestions were put forward, such as improving the medical association system, improving the hierarchical allocation of medical resources, reforming the medical insurance system to guide the hierarchical treatment, improving the drug

catalogue, and building a regional health information platform to realise medical information sharing. This paper provided detailed data analysis and comprehensive improvement methods, but did not involve the problem of big data information processing.

In view of the shortcomings of the traditional methods, this paper studies the innovation of the intelligent monitoring method for bidirectional referral information resource based on big data in the aspects of the relationship between the subject and object of the bidirectional referral information resource monitoring, the monitoring system in structure layer, the data flow level monitoring system and the function modules of the monitoring system. It can effectively shorten the treatment time and reduce the cost of examination, medicine and treatment.

2 Intelligent monitoring of bidirectional referral information resource in hospital

2.1 Resource integration

In order to better realise the intelligent monitoring of bidirectional referral information resources in hospital, it is necessary to integrate the information resources.

Figure 1 Concept map model for intelligent integration of bidirectional referral information resource in hospital
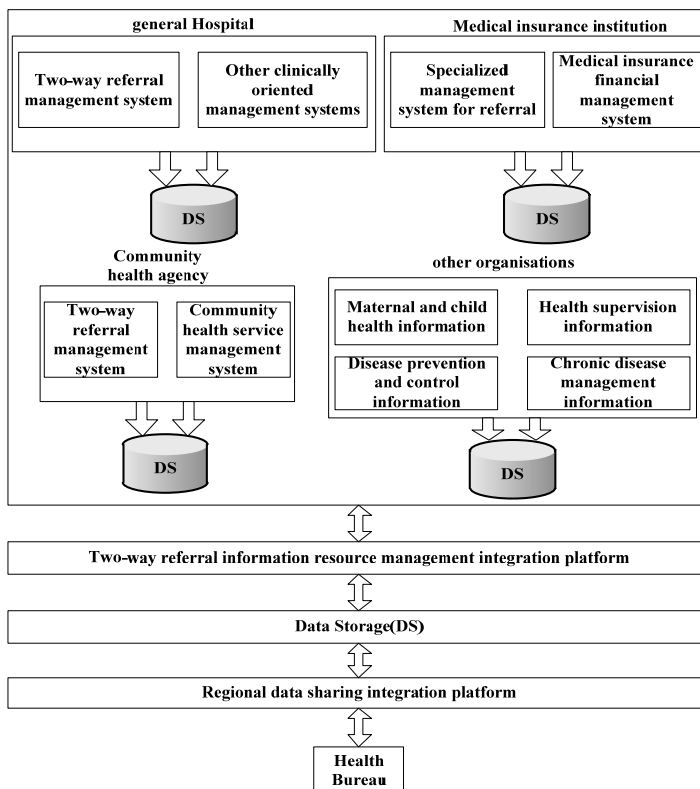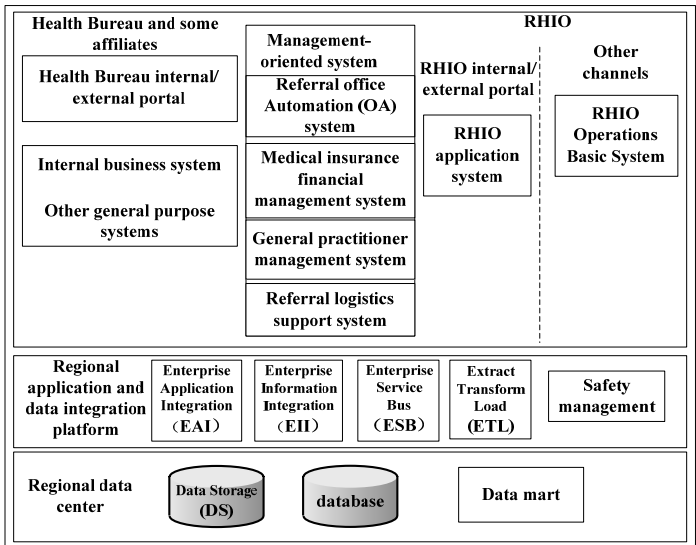
2.1.1   Integration of bidirectional referral information resource

A series of technologies such as message exchange and service interface call are used to carry out point-to-point data exchange among different types of health institution resource systems. This data sharing mode can not be called data integration. The most important key point of data integration in practical sense is to build regional data storage (DS), and at the same time, to design entity unified resource view to complete medical data resource sharing (Abh et al., 2017; Chen and Read, 2016; Dey et al., 2017). Figure 1 shows the concept map model for intelligent integration of bidirectional referral information resource in hospital.

2.1.2   Application structure of bidirectional referral information resources

The selection and construction of application structure elements is one of the key supports for the construction of monitoring system and platform for bidirectional referral information resource. Its main function is to correspond the business function requirements with different application systems, to clarify the boundaries and interrelationships of each application system, especially the bidirectional referral, and to determine how to use cooperation to complete cross system functions. Figure 2 shows the application structure of intelligent platform for bidirectional referral information resource in hospital.

Figure 2   Application structure of intelligent platform for bidirectional referral information resource in hospital


2.2   Two way referral information based on big data

The integration results and application structure of the bidirectional referral information resources are integrated into the design and construction of the monitoring model to provide support for the monitoring with big data. The detailed process is as follows.

2.2.1 Subject and object and conceptual model of bidirectional referral information resource monitoring

Based on the theory of system engineering, the monitoring system is mainly composed of several independent functional modules, interrelated and constrained elements (Henriksson et al., 2016; Lalos et al., 2016). Intelligent monitoring of bidirectional referral information resource in hospital is a system engineering, the overall goal is to achieve efficient real-time monitoring. In order to achieve this goal, bidirectional referral monitoring elements should be based on the subject and object of monitoring and the content of monitoring. The monitoring process should involve all aspects affecting referral. According to the order from admission to rehabilitation, we can define a number of monitoring points, then define the monitoring content based on each monitoring point, at the same time, we can carry out targeted monitoring according to the monitoring organisation. Here, E-R method is used for modelling, and the subject and object and conceptual model of bi-directional referral information resource monitoring can be gotten as shown in Figure 3.

Figure 3 Subject object and conceptual model of bi-directional referral information resource monitoring
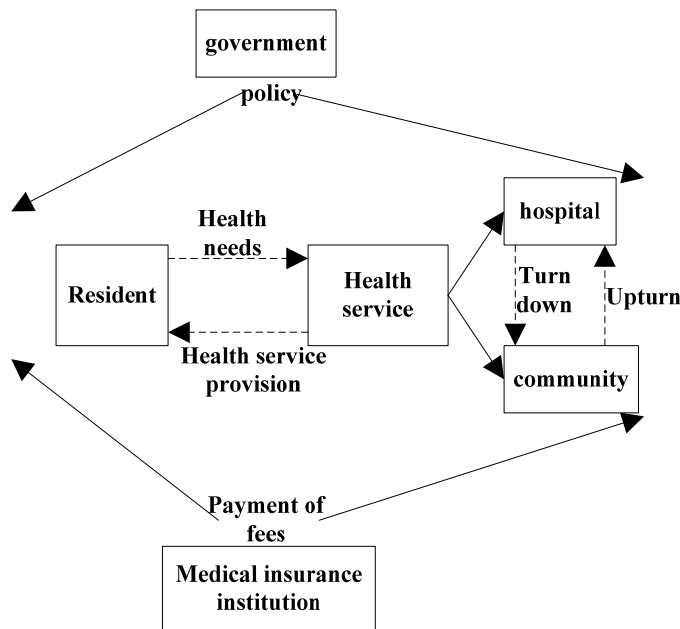
2.2.2 Relevance, content and form of subject and object of bi-directional referral information resource monitoring

The subject and object of the intelligent monitoring system for bidirectional referral information resource in hospital are composed of government functions, communities and other parts. Each element is bound by each other according to the complex relevance. Table 1 describes the monitoring content and main methods corresponding to different subjects and objects.

Table 1   Monitor content and main methods

Main body	Object	Monitoring content	Monitoring method
Government function	Social security department	Social security preferential policies, information disclosure	Independent monitoring
	General hospital	Referral specifications, referral results, information disclosure	Comprehensive monitoring
	Community hospital	Referral specifications, referral results, information disclosure	Comprehensive monitoring
	Patient	Visiting behaviour, referral effect, information disclosure	Public monitoring
Social security department	Government function	Social security related policy system environment construction	Independent monitoring
	General hospital	Social security policy implementation	Independent monitoring
	Community hospital	Social security policy implementation	Independent monitoring
	Patient	Economic behaviour under the control of social security	Independent monitoring
General hospital	Government function	Policy development, information disclosure, business assistance	Independent monitoring
	Social security department	Social security reimbursement, social security policy formulation and adjustment	Public monitoring
	Community hospital	Upward behaviour, information disclosure	Level monitoring
	Patient	Referral behaviour, referral effect	Level monitoring
Community hospital	Government function	Policy development, information disclosure, business assistance	Independent monitoring
	Social security department	Social security reimbursement, social security policy formulation and adjustment	Public monitoring
	General hospital	Downward behaviour, information disclosure	Level monitoring
	Patient	Referral behaviour, referral effect	Level monitoring
Patient	Government function	Policy system, information disclosure, referral dispute handling	Public monitoring
	Social security department	Social security policy, social security reimbursement, information disclosure	Public monitoring
	General hospital	Satisfaction, information disclosure	Public monitoring
	Community hospital	Satisfaction, information disclosure	Public monitoring

2.2.3 Intelligent monitoring system for bidirectional referral information resource of hospital in structure layer

The main components of the intelligent monitoring system for bidirectional referral information resource are community health institutions, relevant medical institutions and medical insurance and health management departments. The implementation of the monitoring system should be based on the following conditions: optimising the hospital information resource system and the community health service system; optimising and standardising the residents' medical and health records. The work of disease prevention and other related health services, diagnosis and treatment services for common diseases and rehabilitation after major diseases are mainly based on community health institutions; patients with severe symptoms and patients with difficult and miscellaneous diseases are treated according to different levels of general hospitals or specialised hospitals; community hospitals report the referral information mastered by their own units to relevant management departments, and work with the medical insurance department (Schneider et al., 2016; Mamlin and Tierney, 2016; Clarke et al., 2017).

Figure 4 shows the data sharing relationship of the intelligent monitoring system for bidirectional referral information resource in hospital.

Figure 4 Data sharing of intelligent monitoring system for bidirectional referral information resource in hospital
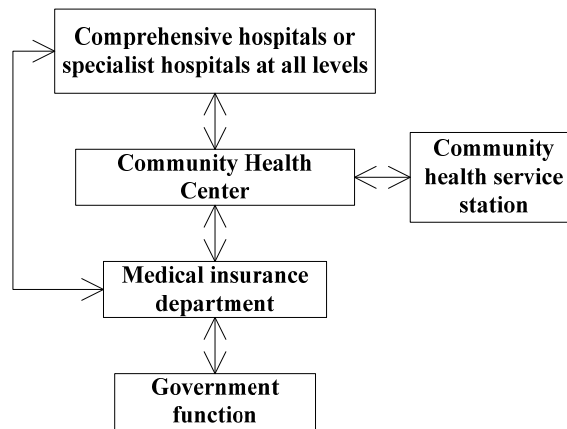
2.2.4 Intelligent monitoring system for bidirectional referral information resource of hospital in data flow layer

In the data flow layer, residents' information files are not only stored in the database of community health institutions, but also transmitted to the regional data exchange service centre. According to the data transmission and exchange relationship in the data flow layer, the designed business data exchange architecture of bidirectional referral information resource monitoring is shown in Figure 5.

Figure 5   Business data exchange architecture of bidirectional referral information resource monitoring
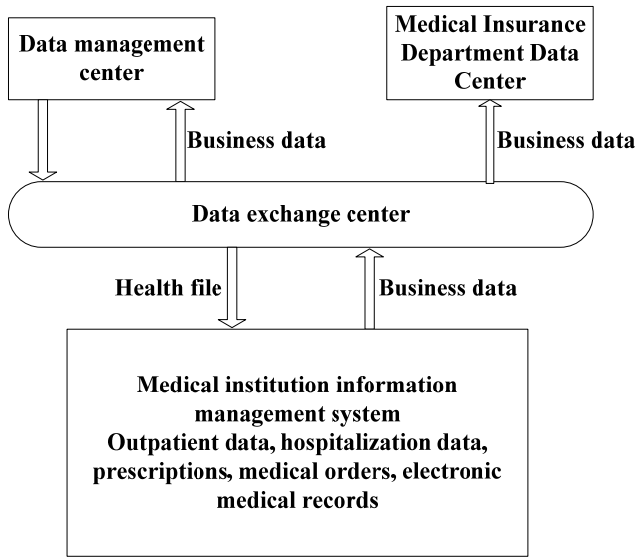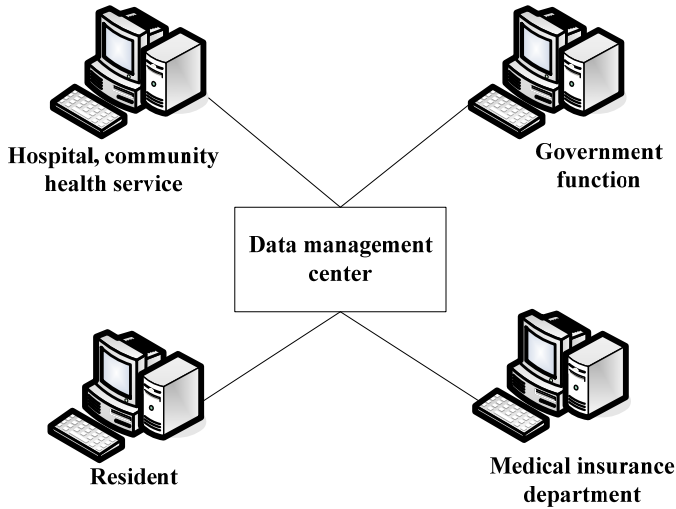

Figure 6   Topology of the monitoring network of bidirectional referral information resource

The main parts of data exchange architecture are information data exchange centre, medical insurance department information data centre and information data management centre. The main service functions provided by the information and data exchange centre are data interface, collection and exchange; the information and data centre of the medical insurance department analyses the information data of referral patients by using collection and statistics and other technologies; the information and data management centre combines the data, management and supervision functions, not only to exchange the information between the structures in the system, but also to realise the unified

management and control of information and data as well as data sharing and utilisation (Wang et al., 2017; Semler et al., 2018; Zhu et al., 2018).

Based on this, the topology of the monitoring network of bidirectional referral information resource is shown in Figure 6.

2.2.5 Function module of monitoring system

The intelligent monitoring of bidirectional referral information resource in hospital involves the business connection between different medical institutions. It requires the hospital's HIS system to add new functional modules, and the main functions are as follows:

a   Generation of referral application: Doctors can use HIS to transfer out the application, describe the patient information and transfer factors, and trigger the internal transfer detailed procedures.

b   Confirmation of referral application: After the transfer application is generated, the relevant departments prepare the corresponding data according to the business process operation standards, confirm the detailed information in the process of patient transfer, and generate the transfer application to be transmitted to the central server of information data exchange (Jo et al., 2017).

c   Acceptance of referral application: When the hospital receives the referral application, it will start the internal admission procedure.

d   Processing of referral application: Based on the application content, HIS of the recipient is allocated to the relevant departments for processing according to the business process. If it is received, the confirmation information is returned and the acceptance method is confirmed at the same time. At this time, the transferor shall provide relevant information and transfer time. Assuming that the rejection information is returned due to information resources and other related factors, and start relevant procedures according to the business process.

Corresponding to the above functions, the information resource system of community health institutions needs to add the following functional modules, and the main functions are as follows:

a   Generation of referral application: Doctors use the HIS of the community to transmit and output the referral application, describe the patient's details and reasons for referral, and start the detailed procedures of internal referral.

b   Confirmation of referral application: After receiving the referral application from other medical institutions, the community medical institutions shall confirm the detailed information in the process of patient transfer according to the business procedure processing standards.

c   Acceptance of referral application: After confirming the next referral application, the internal procedure of accepting patients will be started automatically.

d   Processing of referral application: Based on the application content, HIS of the recipient is allocated to relevant departments according to the business process for corresponding processing. If it is received, the confirmation information will be

returned and the acceptance method will be confirmed at the same time. At this time, the transferor will provide relevant information and transfer time. Assuming that rejection information is returned due to information resources and other related factors, follow-up procedures are started according to the business process.

Based on the function module of bidirectional referral information resource monitoring system, the intelligent monitoring of bidirectional referral path in hospital can be obtained.

Figure 7 Intelligent monitoring of bidirectional referral path in hospital, (a) Intelligent monitoring of bidirectional referral path 1 in hospital (b) Intelligent monitoring of bidirectional referral path 2 in hospital

(a)   (b)
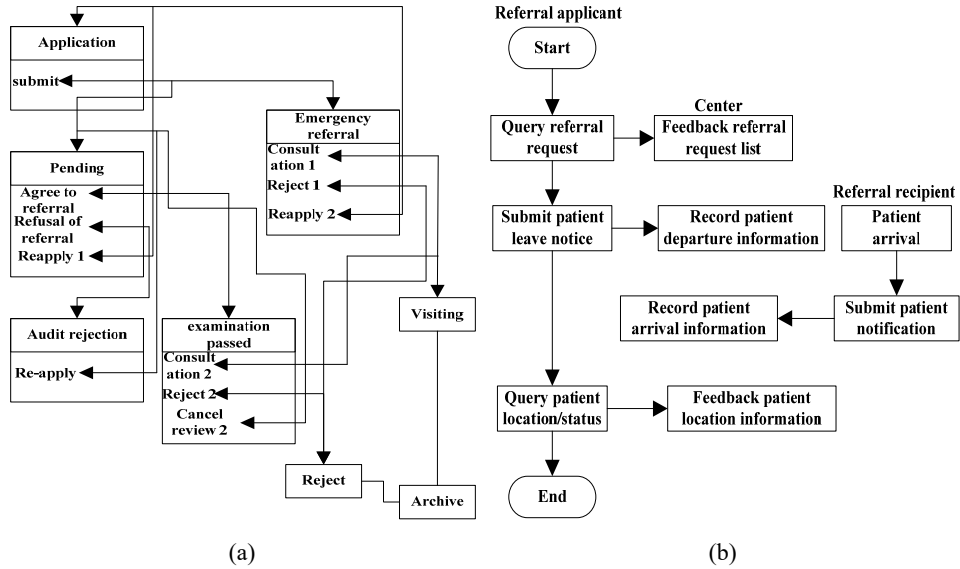
3   Experimental results and analysis

In order to verify that the performance of the intelligent monitoring method for bidirectional referral information resource based on big data is better than that of the traditional scheme, a comparative test experiment between the method in this paper and method of Shen et al. (2017) is designed.

The experimental design is as follows:

The data of the test subjects are bidirectional referral of patients transferred to the central hospital by the community health institutions and subordinate community stations in a city. A total of 15,000 patients are transferred to hospital, including 10,500 male patients and 4,500 female patients. The age ranges from 37 to 90 years old, with an average age of 60.29 years. Two methods are used to process the above information, and the test results are analysed.

Because of the large amount of data, the integrated data is managed through the database part of SAS (SPSS SAS Stata) and the base SAS module. SAS is a modular and integrated large-scale application software system, whose main function is to manage and

analyse a large number of data. The data is stored after distributed processing, and the SAS sensing module is called to build the database. Statistical Product and Service Solutions (SPSS) software is used to pre-process the data, construct the relationship matrix through data relevance, cluster according to different methods, and finally determine the best classification. After statistical analysis of the classification data, select the following indicators, and use this method to compare the existing methods (Shen et al., 2017):

1   days in hospital

2   inspection cost

3   drug cost

4   treatment cost

5   bed cost.

Figure 8   Comparison of monitoring effect of two methods, (a) days in hospital (b) inspection costs (c) drug costs (d) treatment costs (e) bed costs
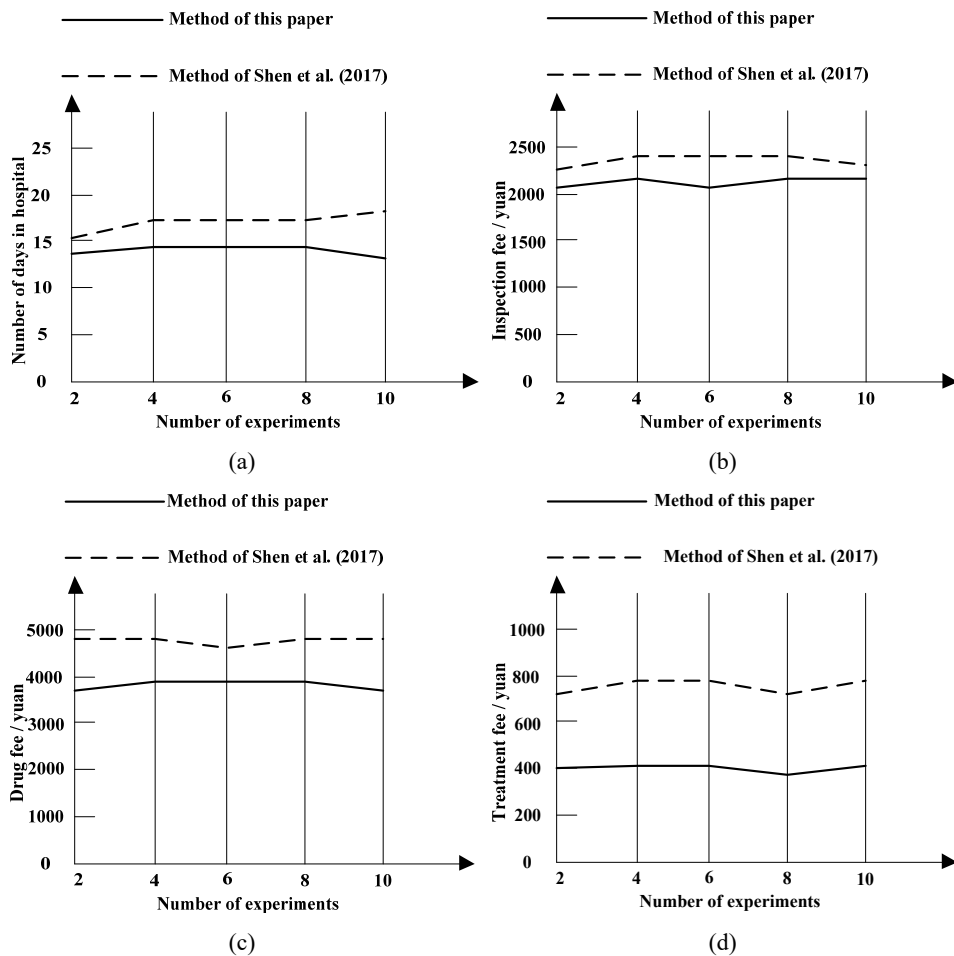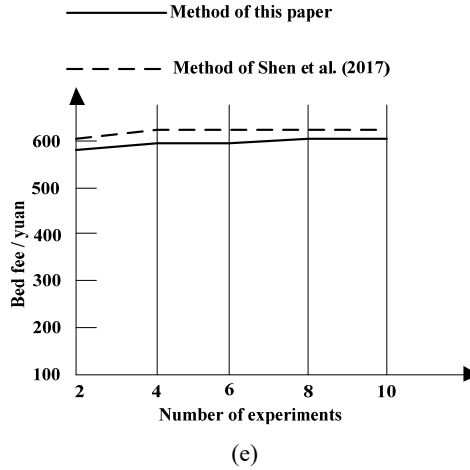
Figure 8   Comparison of monitoring effect of two methods, (a) days in hospital (b) inspection costs (c) drug costs (d) treatment costs (e) bed costs (continued)

(e)

Comparing and recording the above information, the lower the values, the better the monitoring effect of two-way referral resources. According to the statistical analysis, the experimental results are in Figure 8.

The less the patient's days in hospitalisation, examination costs, drug costs, treatment costs and bed costs are, the better the monitoring effect of bidirectional referral resources is, and the more satisfied the final results of supervision and control are with the patients and their families. According to the analysis of Figure 8, compared with method of Shen et al. (2017), the experimental indicators of the proposed method under monitoring are superior, which shows the reliability of the intelligent monitoring method for bidirectional referral information resource in hospital based on big data. This method uses the integration of bidirectional referral information resources and the application structure of referral resources to provide big data for resource monitoring and support for high-precision monitoring. In order to realise the intelligent monitoring of bidirectional referral information resource in hospital, the monitoring subject, object and conceptual model of bidirectional referral information resource, the relationship between monitoring subject and monitoring object, the content and form, the bidirectional referral information resource monitoring system in structure layer, the bidirectional referral information resource monitoring system in data flow layer, the function module analysis and design of monitoring system are used, so as to reduce the medical expenses in all aspects and optimise the relevant indicators, which shows the robustness of the proposed method.

4   Conclusions

The medical industry has always been a hot industry, and the two-way referral is the focus of the medical industry. Due to the lack of research on traditional two-way referral methods, poor timeliness of application, high medical costs, and poor structure of referral resources, we use the big data provided by the integration and application of referral information resources to carry out two-way monitoring of relevant elements of referral, setup a large number of monitoring points, and carry out targeted according to the actual

situation Monitoring, through monitoring information can effectively solve the above problems, this paper proposes a large data-based hospital intelligent two-way referral information resource monitoring method, designed the structure layer, data flow layer and other modules, the design of the comparative experimental results are as follows:

1   The two-way referral monitoring method can effectively reduce the medical cost, improve the efficiency of the medical process, and has strong reliability.

2   This method uses the integration of two-way referral information resources and the application structure of referral resources to provide big data for resource monitoring and support for high-precision monitoring.

3   This method effectively shortens the treatment time of patients, reduces the medical expenses, not only improves the satisfaction of patients, but also has important significance for the follow-up research.

4   This method has some disadvantages. Next, we can study the regulation of two-way referral resources to better meet the needs of relevant personnel.

References

Abh, D.B., Dunlosky, J. and Cavalcanti, R.B. (2017) 'Monitoring and regulation of learning in medical education: the need for predictive cues', *Medical Education*, Vol. 51, No. 4, pp.575–584.

Bi-Directional Referral System [online] https://www.chronicdisease.org/mpage/domain4_referral.

Chen, Q. and Read, P. (2016) 'SU-D-201-03: during-treatment delivery monitoring system for tomotherapy', *Medical Physics*, Vol. 43, No. 3, pp.3334–3334.

Chen, W.C., Ma, Q.Z., Xie, Y.L. et al. (2017) 'Discussion on the policy of hierarchy diagnosis and dual referral in Heilongjiang', *Chinese Health Economics*, Vol. 36, No. 8, pp.13–16.

Clarke, M., De, F.J., Verma, V. et al. (2017) 'Interoperable end-to-end remote patient monitoring platform based on IEEE 11073 PhD and ZigBee health care profile', *IEEE Transactions on Biomedical Engineering*, p.1.

Dey, N., Ashour, A.S., Shi, F. et al. (2017) 'Developing residential wireless sensor networks for ECG healthcare monitoring', *IEEE Transactions on Consumer Electronics*, Vol. 63, No. 5, pp.442–449.

Gao, X., Zhang, X.Y., Li, S. et al. (2017) 'Willingness of down – referral of community residents and its influencing factors', *Chinese General Practice*, Vol. 20, No. 9, pp.1177–1180.

Henriksson, J., Tydã, N.G., Hãjer, J. et al. (2016) 'A prospective randomized trial on the effect of using an electronic monitoring drug dispensing device to improve adherence and compliance', *Transplantation*, Vol. 100, No. 20, pp.203–209.

Jo, H.S., Song, T.M. and Kim, B.G. (2017) 'Analysis of the factors affecting consumer acceptance of accredited online health information', *Journal of Korean Medical Science*, Vol. 32, No. 2, pp.1757–1763.

Lalos, A.S., Antonopoulos, A., Kartsakli, E. et al. (2016) 'RLNC-aided cooperative compressed sensing for energy efficient vital signal telemonitoring', *IEEE Transactions on Wireless Communications*, Vol. 14, No. 2, pp.3685–3699.

Mamlin, B.W. and Tierney, W.M. (2016) 'The promise of information and communication technology in healthcare: extracting value from the chaos', *American Journal of the Medical Sciences*, Vol. 351, No. 15, pp.59–68.

Pierce, C.E., Bouri, K., Pamer, C. et al. (2017) 'Evaluation of Facebook and Twitter monitoring to detect safety signals for medical products: an analysis of recent FDA safety alerts', *Drug Safety*, Vol. 40, No. 3, pp.317–331.

Schneider, R., Randolph, G., Dionigi, G. et al. (2016) 'Prospective study of vocal fold function after loss of the neuromonitoring signal in thyroid surgery: the international neural monitoring study group's POLT study', *Laryngoscope*, Vol. 126, No. 19, pp.1260–1266.

Semler, S.C., Wissing, F. and Heyder, R. (2018) 'German medical informatics initiative', *Methods of Information in Medicine*, Vol. 57, No. 6, pp.e50–e56.

Shen, G.L., Fang, P.Y., Shen, C.D. et al. (2017) 'Investigation and analysis on classification diagnosis and treatment and bidirectional referral in Wuxi City', *Chinese Health Service Management*, Vol. 34, No. 2, pp.501–504.

Tomasic, I., Tomasic, N., Trobec, R. et al. (2018) 'Continuous remote monitoring of COPD patients – justification and explanation of the requirements and a survey of the available technologies', *Medical & Biological Engineering & Computing*, Vol. 56, No. 12, pp.547–569.

Vearrier, D. and Greenberg, M.I. (2017) 'The implementation of medical monitoring programs following potentially hazardous exposures: a medico-legal perspective', *Clinical Toxicology*, Vol. 55, No. 1, pp.1–14.

Wang, G., Zhang, Z., Feng, Y. et al. (2017) 'Telemedicine in the management of type 2 diabetes mellitus', *American Journal of the Medical Sciences*, Vol. 353, No. 6, pp.1–5.

Yu, X.Y. and Sun, R.L. (2017) 'Simulation research on information retrieval of hospital specific patient information', *Computer Simulation*, Vol. 34, No. 5, pp.389–392.

Zhu, T., Zhang, Y., Ye, X. et al. (2018) 'Application of biclustering algorithm in adverse drug reaction monitoring system of China', *Pharmacoepidemiology and Drug Safety*, Vol. 27, No. 4, pp.1257–1264.

Zini, E.M., Lanzola, G., Bossi, P. et al. (2017) 'An environment for guideline-based decision support systems for outpatients monitoring', *Methods of Information in Medicine*, Vol. 56, No. 2, pp.283–293.