“Three-Level, Four-Integration” Internet-Based Smart Medical Platform

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Keywords: Internet-based, Long-distance, Medical, Health care, Platform.

Abstract. To decrease the difficulty of patients in visiting the doctor and receiving quality health care, to enhance the service capacity of community primary health care institutes, and to implement the grading treatment strategies, Ji’nan Central Hospital has worked with Ping’yin County Hospital for the construction of “Three-Level, Four-Integration” Internet-Based Smart Medical Platform. The platform connects with the hospitals’ LIS and PACS systems, explores the mechanisms and models of three-grading health care in four aspects: medical treatment, teaching, research and administration. Its functions include long-distance (1) medical consultation, (2) multidisciplinary consultation, (3) clinical patient case discussion, (4) health education, (5) academic conference, (6) laboratory samples inspection and results reviewing, and (7) medical image diagnosis. As a result, an internet-based smart medical platform has been initially constructed, connecting city, county, and town hospitals, and providing quality and efficient health care services for urban and rural residents in Ji’nan area.

Introduction

Modern medicine is largely dependent on the technological progress of medical equipment. To a certain extent, the advancement level of medical facilities and equipment represent the ability of health care of a hospital. The purchase of high-technology medical equipment requires a lot of capital investment and additional conditions. This results in high technology and precision medical equipment gathering in the large-scale hospitals of big cities but absent in the community primary healthcare hospitals and facilities of small-size cities and rural areas. The development of modern advanced medical science and technology also determines the workforce flowing of healthcare professionals. Along with the grouping of medical technology resources in the big cities, a large proportion of experienced healthcare professionals locate in the large-scale hospitals. This leads to differences in the quality of medical services between large city hospitals and community primary healthcare facilities. At present, the number of community healthcare hospitals and facilities in China has been more than 50,000, which are supposed to be in responsible for more than two thirds of medical services of the nation's population. However, due to the limited number of advanced medical equipment and experienced health care professionals, community health care facilities are not able to take their responsibilities and to meet the needs of patients in receiving quality health care.

Internet-based medical smart platform is an important part of the medical and health system reform [1]. Through the internet technology, internet-based medical system makes quality medical services available to the distant communities and families. Patients of both urban and countryside areas can receive high quality medical service, regardless of geography locations they live. Since 2014, a number of government guidelines have been issued by China’s Health and Family Planning Commission on developing internet-based medical services [2-5]. Internet-based long-distance medical services become an important approach to enhance the service capacity of community primary healthcare facilities so as to promote community health. Therefore, a project, named as “Three-level, Four-integration” Internet-Based Smart Medical(IBSM) platform, is started by the Smart Medical Center of Jinan Central Hospital, Ji’nan, Shandong, China, and Ping’yin County
Hospital, Ping’yin county, Ji’nan, Shandong, China. The two institutes have jointly applied the “Applying Science and Technology to improve the people's livelihood” grant from the Ji’nan Science and Technology Bureau to develop the program.

The Purpose of the Program

The purposes of this project are (1) to develop an internet-based long-distance system that integrates all medical services of both urban and rural areas of Ji’nan city, and (2) to explore a new model for providing high quality-low price, fast and efficient medical service to residents of a far-distance county, Ping’yin. Activities via the system include long-distance clinical consultation, multidisciplinary case discussion, diagnostic imaging, disease management, diagnosis and health education conducted by experienced healthcare providers of the large-scale hospital, Jinan Central Hospital (JCH). In this way, resources of the JCH would be made available to far-off communities. Quality and safety of the community primary healthcare facility, Ping’yin County Hospital, would be improved.

“Three-Level, Four-Integration” IBSM Platform

Under the collaborative efforts of the two hospitals in two years, the platform has developed the following function modules: Data center, Sharing and Exchange system, Resource Management system, Remote Consultation system, Long-Distance Health Education system, and Imaging Diagnostic systems. The platform connects with the hospitals’ LIS and PACS systems, explores the mechanisms and models of three-grading health care in four aspects: medical treatment, teaching, research and administration. Its functions include long-distance (1) medical consultation, (2) multidisciplinary consultation, (3) clinical patient case discussion, (4) health education, (5) academic conference, (6) laboratory samples inspection and results reviewing, and (7) medical image diagnosis.

Data Center

Data center is one fundamental construct of the IBSMP platform. It is also the basis for various medical collaborative services, and is the backbone to achieve the integration and information sharing and exchange within the system. The construction of data center follows the requirements of China’s the Ministry of Health and Family Planning, and develops its appropriate standards system. In the construction process, a major factor taken into account is the smooth linkage between the upper advanced and the lower primary healthcare facilities. The platform data center includes data base, data collection and integration services, data storage, data management, and data sharing and exchange services. The architecture of the data center includes the following five parts: the data source layer, the ODS layer, the topic aggregation layer, the summary layer and the data accumulation layer.

System Management

Individual Main Index

Individual main index (IMI) is the personal identifier of each patient in the system. Through the IMI, information of one patient could be easily located and interacted within the system between the upper and lower healthcare hospitals under the agreement and authorization of the patient and subject to the related local legislation. This is one of the most important functions of the IBSM platform. Another important task of the IMI management is to keep the privacy of each patient under secure preservation. Information under protection includes patients’ personal identifiers (e.g., name, address and phone number) and sensitive medical information (e.g., diagnoses and treatment).
Registration System

The platform provides user registration service to the following agents: (a) health care providers, (b) facilities and medical institutions, such as hospitals, and (c) medical terminology standard registration. In this way, user registration is available to all health care professionals and facilities in the area under a single directory and with a comprehensive and unambiguous identification. Medical terminology standard registration is to map, define and standardize medical terms related to health care activities.

Platform Configuration Management

Configuration management of the platform includes user account management, user rights management, and system self-configuration. User account management is used by institutions to supervise users' behaviors in the platform. User account management performs a comprehensive management of users, including adding, modifying and deleting certain user groups. User rights management is very important in data platform. By authorizations and prohibitions, different users have different access to health information in the system. This ensures the safety, reliability and stability of the system. Through the system configuration, the system carries on the intelligent maintenance to each interface component, provides automatic renewal function, the system parameter setting and personalized service, and so on. For the update of data sets and processes classification, the distribution mechanism is used to ensure the unity of each node.

Operation Monitoring System

Operation monitoring system includes subject management and mode management. Subject Management: medical and health information circulated in the platform are managed by subject. Through the Publish and Subscribe model, health care institutions and departments can publish and subscribe to information in the platform by theme. Node management defines parameter and attribution of each node, and constructs data exchanging environment. At the monitoring end, all network segments and nodes are displayed graphically, and the state of each node is automatically detected.

Long-Distance Multidisciplinary Case Discussion (LDMdCD) System

Using the platform, a group of healthcare providers from both the community and the city hospitals can interactively meet and discuss patient cases through digital video conferences instead of meeting together physically in the real word. The LDMdCD system is composed of three parts: hospital information system, management center and medical expert system. First, the community primary hospital submits a LDMdCD application to the system. Once receiving the request, management center will schedule medical experts, arrange a time for the group meeting of the two sides. The system supports a variety of standard interfaces (DICOM, HL7) and non-standard interfaces such as HIS, EMR, PACS, LIS, CIS and others. Experts can check the patient’s information, ultrasound results, imaging and laboratory test results made in the community, so as to make accurate diagnosis. In addition, in the discussion session, the system can integrate a variety of audio and video files, high-definition videos and high fidelity audios to achieve a smooth communication between the two sides of discussion.

Long-Distance Imaging Diagnosis System

This system is to share and exchange medical image information between healthcare institutions, departments and healthcare providers. Medical image information sharing is Web-based, PACS imaging diagnosis software product, which has various functions of the PACS browser, and supports the image-reading report upload. Multiple data sources are supported and lossless compression of DICOM image transmission are used.

A variety of large medical equipment images can be displayed in the system, such as CT, MR, CR, DR, RF, US, ES, PS and other devices. The main function of image processing include image
zoom, annotation, rotation, inverting, moving, length measurement, angle measurement, area measurement, central line measurement, pseudo color, magnifying function and region of interest display. Formats can be converted into JPG and BMP. The system also allows to print image, and film. Users can retrieve DICOM information, test history, set row and column, and see the sequence play of stack image.

Imaging diagnosis system includes three modules: the application module, health provider module and backstage management module. The application module can initiate application and registration. Health provider module is used to view image information and provide corresponding diagnosis. To help with image interpretation, providers can fully access to the patient’s health information in electronic medical records. Backstage management includes basic information management, costing management, related statistical analysis and account management.

**Long-Distance Health Education System**

Fundamental application functions include Video on demand, Courseware on demand, Video broadcast and Live Video broadcast. Client terminal can be free to request audio and video education programs in a variety of streaming media formats in the remote or local area network. Users can also access to education materials in the formats of text, pictures and animation, etc. The system can also broadcast video to all remote and/or local users. As long as connecting to the network, users can receive broadcast programs. In addition, video sources can be collected from other sources in real time acquisition, simultaneously recording and live broadcasting to all users of the platform. Users can watch live programs online.

**Summary**

In one year and six months, a total of 35 long-distance health education sessions, 26 professional academic conferences, and five long-distance multidisciplinary case meetings have been completed via the platform. The number of persons benefited has been more than 4000. An internet-based smart medical platform has been initially constructed, which connects city, county, and town hospitals and provides quality and efficient health care services for urban and rural residents in Ji'nan area.

**Acknowledgement**

This work was supported by the “Applying Science and Technology to improve the people's livelihood” grant (201406001) from the Ji’nan Science and Technology Bureau, Ji’nan, Shandong, China.

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