ELSEVIER

Computers in Biology and Medicine 38 (2008) 446–460

Computers in Biology and Medicine

www.intl.elsevierhealth.com/journals/cobm

A bilateral integrative health-care knowledge service mechanism based on 'MedGrid'

Chao Liu, Zuhua Jiang*, Lu Zhen, Hai Su

Department of Industrial Engineering & Logistics Management, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China

Received 29 May 2007; accepted 14 January 2008

Abstract

Current health-care organizations are encountering impression of paucity of medical knowledge. This paper classifies medical knowledge with new scopes. The discovery of health-care 'knowledge flow' initiates a bilateral integrative health-care knowledge service, and we make medical knowledge 'flow' around and gain comprehensive effectiveness through six operations (such as knowledge refreshing…). Seizing the active demand of Chinese health-care revolution, this paper presents 'MedGrid', which is a platform with medical ontology and knowledge contents service. Each level and detailed contents are described on MedGrid info-structure. Moreover, a new diagnosis and treatment mechanism are formed by technically connecting with electronic health-care records (EHRs).

Keywords: Knowledge management (KM); Knowledge flow; Bilateral integrative; MedGrid; EHRs; Ontology; TCM; Health-care knowledge

1. National policy-oriented development toward TCM

March 20th 2007, the compendium of 'Innovative development and program on Traditional Chinese Medicine (TCM) (2006–2020) [1]' (National Scientific and development, 2007, No. 77) was published by Chinese scientific and technology department, hygiene department, National TCM administration, etc. 16 ministries and commissions, which aims at propelling mutual fusion between conventional biomedicine and TCM. The new policy advises to establish a sharing mechanism so as to manage the whole health-care achievements and knowledge well enough. Furthermore, the government vigorously supports to establish biomedical collaborative communities based on modernization of TCM. Meanwhile, to solve the public 'difficult and expensive when getting disease treatment' problem, TCM should play an important health-care role in both convenient examinations and cheap tests, improving organization's health-care standard and reducing whole medical costs. Thus, this compendium has pointed out the right direction for developing the informatization of TCM, will write a few new chapters.

The discussion proceeds as follows. In Section 2, we *highlight* the indispensability of knowledge management (KM) after analyzing the background of the compendium and *give* true reasons that lead to knowledge deficiency in healthcare areas. What is more, we also *present* a new classification toward modalities of health-care knowledge. In Section 3, we *discover* a kind of knowledge flow in medical field, based on which substantial advantages emerge when bilateral disciplinary integration is made between conventional biomedical and TCM. Then, a novel knowledge flow mode between in and out of medical organizations is *described* clearly and is next introduced in Section 4. Whereas in Section 5, we *discuss* the concept of Medical Grid (MedGrid), based on medical ontology and electronic health-care records (EHRs), which helps practitioners to use standardized health-care knowledge instead of just pieces of information even data to simply store and search functions. Further, Section 6 *deploys* a kind of Web-based bilateral integrative MedGrid platform for diagnosis and treatment. Finally, Section 7 *provides* concluding remarks and some thoughts for the future of KM techniques in health care.

* Corresponding author.
E-mail addresses: lucascrystal714@yahoo.com.cn (C. Liu), zhjiang@sjtu.edu.cn (Z. Jiang).

0010-4825/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compbiomed.2008.01.007

2. Health-care medicine starves for KM

A variety of untapped, highly specialized health-care knowledge are scattered around in hospitals. However, because of the severe ignorance toward this kind of knowledge and lack of collecting, sharing, distributing and re-applying them, it seems to be the instrument of knowledge paucity under current medical market. Consciously or unconsciously, it is KM that provides health-care managers some crucial techniques with a brand new views and ideals on controlling whole medical knowledge. For instance,

(1) *Knowledge acquisition* collects information then converts it into useful knowledge, in particular, focusing on nonarticulated practitioners' experiences.
(2) *Case-based reasoning (CBR)*, together with EHRs, helps practitioners make quick, correct clinical diagnosis.
(3) *Knowledge map* can navigate critical medical resources, including valuable equipment and invaluable practitioners in and out of organizations, and support to make a decision.
(4) *Knowledge supply*, featuring in diverse requirement characteristics, can make sure that the right medical knowledge are transferred to the right person (patients or doctors) at the right time and the right place.
(5) *Knowledge flow techniques* can propel entire knowledge sharing and exchanging in and among organizations so as to accumulate well and exert them effectively.

The emergence of KM as a new discipline and its profuse application to health care can solve the current operational and technical barriers toward the recognition, acquisition, dissemination and utilization of actionable health-care knowledge [2].

2.1. The dilemma of health-care knowledge

The current health-care market needs new therapeutics, new technologies, good medical service-qualities but patients pay a lot of attention to curative effects instead of treatment process, therefore many hospitals are in the face of specialized health-care knowledge paucity [3]. In some fields, medical techniques have lost advantages and actionable health-care knowledge innovation is severe deficit. Actually, health care is a knowledge-rich and comprehensive domain. Yet, due to various operational and technical reasons, the various modalities of medicine and health-care knowledge are not entirely harnessed and put into practice, thus causing some false feeling of paucity of knowledge in health care [2,3].

On the one hand, general medical knowledge can be codified and copied even quickly learned. On the other hand, doctors have so much implicit area knowledge in their mind, personal experience that they are not able to write out, even not describe them. However, we believe that such implicit knowledge modality will be substantially available through professional behaviors, because they are embedded in doctor's practical behavior. Therefore, implicit medical knowledge is as important as general medical knowledge. The solution is if we find the right way to dig implicit knowledge out, such dilemma will disappear.

2.2. New classification of health-care knowledge under perspective of KM

Type of knowledge is either explicit or tacit [36]. Explicit knowledge can be expressed in words and numbers, scientific formula, codified procedures, and therefore, they are easily communicated. In contrast, tacit knowledge is intangible because it represents intuition, subjective insights, beliefs and expertise [37,38]. But, this is not accurate enough to describe health-care knowledge, according to the features of specialized, scattered, bilateral simultaneous participating in process, we classify the healthcare knowledge into three types, namely *explicit knowledge, grey knowledge and black knowledge*. And they are:

(A) *Explicit knowledge* (*large and detail*)—a kind of easily acquired and frequently learned, codified by ICD-10 and well-expressed medical knowledge which is structuralized. Such as *diagnosis record templates*, *practitioner's regulation or rules*, *biomedical literature and journals*, *taboo dictionary*, *PACS/CT*, *the manual operation of nursing workstation and clinical guideline*, *etc.* [4].
(B) *Grey knowledge* (*enormous to omnipresent*)—a kind of hard-to-gain, but through communication among doctors or interaction between practitioners and patients, this kind of health-care knowledge can be converted into explicit knowledge by the extroverts. Such as *clinician technique from the experienced*, *surgery details*, *manipulation methods*, *insights of unknown diseases, etc*.
(C) *Black knowledge (small and important)*—a kind of extremely desirable, nonarticulated knowledge [5], which can be obtained only through introvision, totally personal capability. Such as *gut feelings*, *talents*, *cognition*, *beliefs and professional virtues*, *etc.*

Table 1 gives the general idea about a large quantity of health-care knowledge in hospitals and its different ownerships. We notice that only human beings own the black knowledge not any organizations like hospitals. From the standpoint of KM, what truly causes hospital's healthcare knowledge deficiency is the ineffective usage of rich and reliable, dispersed and desirable grey and black kind health-care knowledge. The fact is, the healthcare experts own far plentiful experiences and insights than explicit knowledge [6,7], most of which are stored in EHRs [8–10]. EHRs manage health-care knowledge in terms of formalization and standardization. In addition, [11,12] believe that huge grey and black kind health-care knowledge will play an indelible role in the process of biomedical technology innovation.

It is similar to *Freud's iceberg theory* [13], which is so famous that it clearly explains how people behave and why they are doing this in their career even daily life. Fortunately, in health-care area, as we argue, there are three important modalities of health-care knowledge, which we regard it as *knowledge iceberg* (see Figs. 1 and 2.). Such modalities are made up by explicit knowledge, grey knowledge and black knowledge. The whole health-care knowledge is just like an iceberg