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Design of an Early Warning System for Patients with Cardiovascular Diseases under Mobile Environment

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Abstract

We proposed a framework for early warning of Cardiovascular diseases (CVDs) under mobile environment, which is a real-time and personalized problem involving various complex knowledge. Specially, the principles and methods for early warning are proposed, as well as the selection and collection of key indicators. The system integrates patients and families, physicians, hospitals and community clinics, which consists of two tiers. The mobile device tier could detect the abnormal situations of the patients, and the service center will discover and refine the knowledge of personal situation which could increase the effect and efficiency of CVD's early warning.

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1. Introduction

Cardiovascular diseases (CVDs) have become the number one killer of the residents in China with the characters of high morbidity and fatality rate. Data released by the Ministry of Health in 2012 showed that the number of patients with CVDs in China has increased to more than 270 million and almost 3 million patients' died of CVDs which accounts for 41% of the total patient deaths. Annual medical costs for CVDs has reached to 130 billion RMB. The treatment effect of CVDs is decreasing with the passage of time, for example, 25% patients are dead before reaching

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the hospital after CVDs erupted, and most of the survivors are left with varying of sequelae. Therefore, an effective early warning of CVDs to extend the time for first-aid treatment, has an important significance to 270 million CVD-patients in China.

Since the onset of CVDs is full of suddenness and uncertainty, which will lead to the following two consequences. (1) The first one is over treatment, which means that even though the risk is low, the patient still tends to stay in hospital for observation for a longer time, resulting in a tremendous waste of medical resources. (2) The other situation will be the delayed rescuing - once the CVDs attack a patient in their daily life, the professional medical equipment are often far away from the site, which consequently increase the difficulty in timely and appropriate rescuing. In recent years with the development of IoT (Internet of Things), the concept of “Hospital to Home” has been realized step by step, which could ease the current situation of hospitalizing, and increase the medical resources utilization. On the other hand, an effective early warning of CVDs can prolong the rescuing time, relieve the worries of patient’s family, and guarantee the safety of patients at the maximum level.

The innovative IoT technologies have opened up the new fields in intelligent and mobile health care area, and also bring opportunities for CVDs care. Particularly, mobile health care, as a new hospitalizing model, will change the traditional medical patterns of doctor-seeing, monitoring and medical care. A new industrial chain has been formed gradually. It is expected that by the end of 2017, the market scale of mobile healthcare in China will reach to about 12.53 billion RMB, then there will be 3 million mobile devices connected to the “medical LAN” in ubiquitous wireless networks. Moreover, the wearable medical sensors will exceed 100 million units.

However, there are several important issues lie in the intelligent health care, for example, law issues, data security, personal privacy, lacking of professionals, to name a few. And the key question is the inadequate level of intelligence of the devices because of the complexity of medical knowledge. Therefore, exploring the intelligent early warning methods under the mobile environment to identical the real dangers of the patients quickly and correctly is most important for improving the standard of health care in the name of intelligence.

The paper is organized as follows. Literature review on the current related work is conducted in Chapter 2, followed by a detailed analysis of the problem and the basic rules of the system design in Chapter 3. Section 4 introduce the choosing of key indicators as well as the early warning methods. The early warning platform are shown in Chapter 5. Finally we conclude our study in Chapter 6.

2. Literature review

We hereinafter review the most related research areas to our problem, namely (1) the medical or clinical results of CVDs and (2) real-time abnormality detecting technologies and platforms.

For CVDs, plenty of research has been conducted from the perspective of medical statistics and try to obtain the key factors of CVDs evolution from the external environmental factors, individual living habits, inherent personality factors and pathological point of view. Sundell et al. (2008)^[1] reveals that smoking is the secondary cause for the male’s CVDs morbidity and mortality, and obesity and overweight are individual risk factors for CVDs. The relationship between the time occurrence and blood pressure has been studied by Verdecchia et al. (2012)^[2]. Experiments conducted by the group of Japan Morning Surge-Home Blood Pressure Study Investigators compared the nighttime home blood pressure and hospital blood pressure and conclude that the added blood pressure testing and monitoring at home could increase the ability of risk assessment (Ishikawa, et al. 2012)^[3]. The effect of lipid levels on the incidence of CVDs have been investigated (Zeng, et al., 2008; Wang, et al., 2008)^[4-5]. Many scholars focus on the meteorological factors, for example temperature, air pressure, wind speed, to name a few (Shaposhnikov, et al., 2013; Zheng, et al., 2013; Yue and Shen, 2009)^[6-8]. In addition, personal factors such as character, exercise habits also have a great impact on the incidence of the disease (Yang, 2003)^[9].

On-line abnormality detection is an important research branch originated through combination of health care and artificial intelligence. Hong et al. (2011)^[10] developed a condition-based monitoring of patient behavior and the indoor air quality for syndromic surveillance of chronic disease, which could automatic prevent risks and detect abnormality in time. Charbonnier and Gentil (2010)^[11] proposed a multivariate trend extraction method for an alarm validation system using fuzzy decision making. The results indicate that the false alarm rate is up to 85% when using single indicator. Moreover, in order to reduce the false alarm rate, it is important to use multi-sources data and to concentrate on the relationship between them. A sliding windows based data stream processing is an effective method for real-time data statistics under resource constrains (Zhou et al., 2008; Datar et al., 2012)^[12-13]. However, due to the

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