Clinical Application of Decision Support System for Treatment of Migraine

Lin Hui, Huan Chao Keh, Meng Chu Chiang and ZhenYao Liu

Abstract In this modern society, migraine belongs to a kind of common disease. The hospitals begin to use clinical decision support system a lot to improve the accuracy of diagnosis, this kind of system can help the physicians make the decisions and give a treatment by entering the information of the patients in advance. In the treatment of migraine, the patients need to keep diaries of headache, the physicians can make a diagnosis and trace according to the diaries. In this paper, we come up with constructing a clinical decision support system for treatment of migraine. We use the headache diaries as data, in order to store the data easily, we transform paper diaries to electronic diaries first, store the data in the databases of the servers or the mobile platforms (e.g. smartphones, tablet computers), and the data can be shown on the front-end interface. We also make use of data mining to analyze the factors, medicines and associations of migraine, and the result will be recorded in the system to improve the efficiency of the physicians' inspection.

Keywords Migraine · Clinical decision support system · Data mining

1 Introduction

1.1 Definition

Migraine is a common disease in the world, it is not only caused by psychological factors, it is a physiological disease, for example, the change of brain chemicals; The HIS (International Headache Society) put forward the standard of the diagnosis

L. Hui (✉) · Z. Liu
Department of Innovative Information and Technology,
Tamkang University, Yilan County 26247, Taiwan
e-mail: amar0627@gmail.com

H.C. Keh · M.C. Chiang
Department of Computer Science and Information Engineering,
Tamkang University, New Taipei City, Taiwan

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of migraine, and make more detail description and definition of this symptom. According to the report of The World Health Organization, that migraine is one of the four major chronic diseases lead to disability, although migraine does not lead to life-threatening, but will seriously affect the patient's life, work and the family status. Migraine and its sequel will not only increase unemployment, disability benefits and medical costs, also lead to the economic loss of the USA for 17 billion dollars a year [1]. In Taiwan, Taipei Veterans General Hospital had the statistics of migraine epidemiology [2], the prevalence that Taiwanese suffering from migraine is about 9%, it means in Taiwan, there are about 1.5 million to 2 million people suffering from migraine. And the degree of severity of migraine of each patient is different. Now it is not sure that which kind of reason lead to migraine, but according to the present studies show that [2], because of the stimulation of the diet or the environment, the patients may be leaded to migraine, just like the change of the neurotransmitters in the brain, such as the change of concentration of serotonin, will lead to a series of pain. In order to track the status of the patients more clearly, doctors advise that the patients can get into the habit of keeping a diary, record the time of the onset of the headache every time and the time the headache lasts, if there is a sign or not before the onset and the seizure frequency, next time the diary can help the doctor do the diagnosis and it can also be the reference of the follow-up treatment.

1.2 Objective

The purpose of this research project is mainly that we expect to design a system that can help the physicians track the migraine, the type of the system is Clinical decision support system, using this system can put forward the record of the patients' headache to provide the doctors with the reference of diagnosis and help them make a decision. We hope we can help hospital transform the paper record of the headache diaries they provide to digital information, and transform it into a mobile application, avoid the disadvantage of the paper diaries that they occupy space and they are not easy to store, the paper diaries are suitable to use for a short record, but most of the patients need to do a record are suffering from chronic migraine, the onset of them are mainly for years, this will make the data difficult to store and analyze, so we hope the patients do the record of headache on the mobile platform, but based on that some of the patients don't used to use mobile platform and some of them are too old, we will still keep the part of the paper record, although it will improve the difficulty of storage and statistic.

2 Related Work

2.1 The Classification of Migraine

IHS in 1988 put forward the criteria for the diagnosis of migraine, and gave clear definitions and descriptions of migraine, they have divided the headache into 7 types (Table 1), but we only talk about two kinds of Standard of Diagnosis of migraine, migraine without warning and ominous migraine (Table 2). So-called omen is defined as from changing gradually to more than 5 min at least and fewer than 60 min, and neurological symptoms can completely restore. Common are: Omen visual symptoms 'Unilateral paresthesia' one side weakness and inarticulate, and the time from a warning to the migraine cannot be more than 1 h, moreover there may be premonitory symptoms and postdrome symptoms during a few hours to 1–2 days of the onset of the migraine, including the combination of different symptoms, such as fatigue, hard to concentrate, neck stiffness, sensitive to light or sound, nausea, blurred vision, yawning, pale [3].

Table 1 The classification of migraine

The classification of migraine	
1	Migraine without aura
2	Migraine with aura
3	Ophthalmoplegia migraine
4	Retinal migraine
5	May be the precursor of migraine related symptoms of Periodic syndrome in children
6	Complicated migraine
7	The diagnosis of migraine is not in conformity with the above standards

Table 2 The criteria of diagnosis of migraine without warning and ominous migraine

Migraine without warning	Ominous migraine
A. At least five times can match the onsets of B–D B. The onset of the migraine lasts 4 to 72 h C. Headache with at least two of the following features: 1. Unilateral 2. Pulsation 3. The moderate or severe degree (daily activities by limiting or banning) 4. Up and down the stairs, or similar daily activities will make the headache worse D. When a headache attacks there may be at least one of the following circumstances: 1. Nausea or vomiting 2. Photophobia and afraid of noisy	A. At least twice can match the onset of B B. With three of the following four features: 1. More than once ominous symptoms can restore fully, shows local cerebral cortex and (or) brainstem dysfunction 2. At least one warning symptoms gradually appears in more than 4 min, or more than two kinds of symptoms occurred 3. Warning symptoms last less than 60 min, if there are more than one warning symptom, the duration also increases with the increase of proportion 4. Headache attacks about 60 min after warning (also can be before the warning or together with the warning)

2.2 Chronic Migraine

The US Food and Drug Administration (FDA) defined the chronic migraine as the headache's time is 15 days each month and more than 4 h every day. Various symptoms such as pain, afraid of light, afraid of noisy, nausea, often aggravate along with the intensification of activity, and affect the daily life, but want to use drugs to maintain normal daily activities and work productivity, may lead to drug dependence. The early stage of the course of disease of chronic migraine is usually episodic migraine, at the beginning, seizure frequency of the headache is less than two days each week, then the headache will frequent seizures gradually (more than 15 days each month), 8 days of 15 days performing as migraine conforms to the diagnosis of chronic migraine. It is estimated that each year, about 3% of patients with paroxysmal migraine will progress into chronic migraine [4].

2.3 Common Migraine Treatment

According to the treatment of migraine, International SOS provided that the migraine can be divided into two parts: acute headache and chronic recurrent headaches.

Acute Headache

Most of the patients need most is quiet and rest, noise and strong light will aggravate the headache. It will help a lot if the patents can lie down in the quiet and dark room, if they can sleep, when they wake up they will have an obvious relief on their headache. If they have a severe headache, painkillers such as aspirin, paracetamol can also relieve the pain. Other prescriptions doctors commonly used to treat migraine are Cafergot, Non-steroidal anti-inflammatory agent and a new generation of migraine pain killers—Imigran. The drugs of acute attack should be taken as soon as possible, the best time to take the medicine is the time the warning appears or the beginning of the headache, if patients take medicine at the peak of the migraine, usually slow action cannot save a critical situation, and the effect is limited.

Imigran and other Selective serotonin catalysts (this kind of medicine is collectively called as 'Triptans'), can restrain meningeal vascular and brainstem serum tension element receptors, provide more choices for the treatment of migraine, it is best to take medicine in 40 min of the headache attacks or before the warning of the headache, the early to take medicine, the better the results [5]. Although this kind of drugs is expensive, there is a pay limit of the health insurance, the effect is good, currently the medicine that Taiwan headache medical association suggested include Propranolol, Topiramate and Valproic acid, are the first line drugs in the hospitals [2]. Besides drugs, recuperate in life, the good life habit, sufficient sleep is not too much, avoid overfatigue, etc., can also relief the condition of headaches. Some patients may have special inducing factors, such as food, alcohol, temperature changes, if it is found that these conditions, the patient can remind themselves,

avoid similar status, can prevent migraine. In addition, regular exercise, especially aerobic exercise, such as jogging, swimming, riding a bicycle, etc., can improve health and prevent headaches. Patients also need to record their headache condition at any time, the project of record can refer to the headache diary that designed by Taiwan headache medical association (Fig. 1), next time the physician can make diagnosis by referring to the diary.

Headache Diary - VGH

Date : _____Y_____M ID : _____ Name : _____

Intensity (0= no headache 1=mild 2=moderate 3=severe)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Morning															
Afternoon															
Night															
Sleep															
If you have the following symptoms, please tick															
Nausea ?															
Vomiting ?															
Sensitive to light ?															
Sensitive to sound ?															
Throbbing ?															
Unilateral onset ?															
Worsened by physical activities ?															
Aura before headache ?															
Visual aura															
Other aura															
Headache duration hours/day ?															
Preventive medications															
Acute treatment, working or not ? (0=no 1=a little 2= effective 3= very effective)															
Menstrual period, please tick															

Fig. 1 Headache clinic special paper headache diary

Chronic Recurrent Headaches

Effective treatment goal is to reduce the frequency of headache to the standard of paroxysmal headache and accept preventive treatments. If migraine sufferers appear the following symptoms, you may need to take preventive medicine: (1) Headache attacks every month more than twice (2) The onset time is long, more than 48 h (3) The degree of headache is very serious (4) acute treatment often cannot completely relieve pain (5) The time of omen of headache is too long. The main medicine to prevent headache in the hospitals are: β-blockers, Calcium blockers, antidepressants, 5HT2 receptor antagonist, antiepileptic drugs and so on, according to the condition of patients, physicians can prescription for different types of medicine [6]. These drug prescribing appropriate, can get the result of treatment and prevention, but to determine the effect of suspension and no rebound effect, may need treatment for more than two to three months, also need to combine with cognitive behavior therapy, psychological treatment, drug therapy and physical therapy to achieve control of headache.

OnabotulinumtoxinA (commodity name Botox), is the only one drugs that the United-States Food and Drug Administration (FDA) approves to use for chronic migraine. Courses include 155-unit injection to specific areas in head and neck, and through clinical trials confirm therapy (PREEMPT) injection once every three months. Botox injection effect will be decreasing over time, so usually require multiple doses. After treatment, the patents can do an assessment that if they can stop injection or extend the injection interval according to the frequency of onset of the migraine [7].

2.4 Clinical Decision Support System

Clinical decision support system (CDSS or CDS), Its purpose is to help physicians and other health care professionals provide decision-making tasks. For example, when you need to perform a specific diagnosis, CDSS can do further specific testing or treatment. And the concept of it is updating constantly. The definition of the current mainstream job is proposed by Robert Hayward: "Clinical Decision Support systems link health observations with health knowledge to influence health choices by clinicians for improved health care" [8]. Although in the society of information explosion, the physician can get all kinds of useful health information on the Internet, but most of all on the Internet is the electronic format, lead to that physicians lack of information skills and time to find and evaluate the information they need, CDS may be complement of the part for the physician. In terms of strategic purpose, CDS may allow doctors began to use computers, handheld devices and other electronic devices to contact related clinical knowledge, to confirm prescription drugs, refer to all kinds of medical practice, communication with the other physician and interview patients to provide more high-quality medical education [9]. CDS covers a variety of tools, in order to improve the

decision-making process of clinical work. These tools include computerized warning to remind nurses and patients, clinical guidelines, the order of the specific conditions, the key patient data reports and the summaries, document templates, help diagnosis and provide the relevant reference information, etc. [10]. CDS is designed to be a kind of application that the physicians can use it in the clinical operation, input the data of the patients to CDS, CDS will provide some relevant information, such as: possible diagnosis, the alarm of drug interaction or prompt list for preventing disease, etc., Table 3 [11] for a variety of types of CDS, from the table, as shown in the CDS can be applied to solve a variety of different conditions and has the potential to improve the quality of medical treatment. From literature, using CDS to do prevention and management of chronic obstructive pulmonary disease (COPD), they finally worked out by the CDS can solve about the discovery of COPD diagnosis and layered, case management, and send high accuracy diagnosis suggestion to the doctors can also be used in helping to discover new cases of COPD [7] (Table 4).

2.5 Data Mining in the Field of Medical

In any advanced diagnosis or treatment process contains some diagnosis and intervention, sometimes even more. In any such data collection medical institutions or the useful lists are necessary. Because of the appropriate database between medical institutions and the network system, all appropriate data or images are easy to reach [12]. Data mining in medical research are: Chen Shiyuan [19] from the medical records, looked for the relationship between cases and drug use, and hope that through the data mining technology, prevent drug abusive problems in the

Table 3 A variety of cases of CDS

Types of CDS	Cases
At least five times can match the onsets of B–D	At least twice can match the onset of B
prevention and healthcare	Immunization, screening, disease management guidelines, secondary prevention
Diagnosis	Put forward the proposal according to the symptoms and diagnosis of physical characteristics of the patients
Planning and implementation of treatment	Treatment principle, the recommended dose of drug, drug interaction warning
The follow-up management	Order inference, reminding monitoring of drug adverse event
Improve the efficiency of the hospitals	The minimum residence time of health plan
Reduce the cost and convenience to improve the patients	The caution of repeating the test, prescribing guidelines

Table 4 Cases of data mining in the field of medicine

Name	Data mining algorithms	Mining content
Heart disease	Association Rule and decision tree	Use a single data to excavate standard of diagnosis of heart disease and the treatment of heart disease, using mixed data mining to compare the relationship between the heart disease diagnosis and treatment [14]
Cardiovascular disease	C4.5 algorithm	Use data mining to find out the cause of the cause cardiovascular disease, the results can be used in clinical medicine [15]
Diabetes	Apriori and FP-Growth	Use data mining to classify the correlation between different types of diabetes from diabetes database [16]
Lung cancer	Decision tree	Use mining biomarkers NSCLC to predict the type of lung cancer is a new type of lung cancer or other unknown [17]
Seasonal flu	SOM (Self-Organizing Maps)	Use SOM algorithms to analyze the data of infectious diseases, mainly mining under a certain time the spread of infectious diseases in different parts of the mainland China features [18]
Stroke	K-mean and decision tree	Analyze links with interesting degree of correlation analysis model in the database of Chinese and western medicine stroke patients to establish a stroke patient's condition prediction model

health insurance system; Wu Suying [20] used data mining technology to build a hospital disease classification of knowledge management system; Tang Shousheng [21] used data mining technology in tuberculosis patients' medical prediction, etc. We list some cases of data mining in the field of medicine.

3 Research Method

This study constructs a special migraine clinical decision support system, provide doctors tracking and diagnosis of the patients with headache. And together with a hospital in Taipei, this study uses the paper headache diary used by hospital neurology clinic of migraine, convert them to comply with all kinds of action platform software 'electronic headache diary', the patients do the record by themselves on the mobile platform, then update to the database, physicians and patients can bring up the records from the front-end interface by themselves. Therefore, this study of Fig. 2 step as the research method, research steps in order to complete in accordance with the picture stage target, finally construct a complete system.

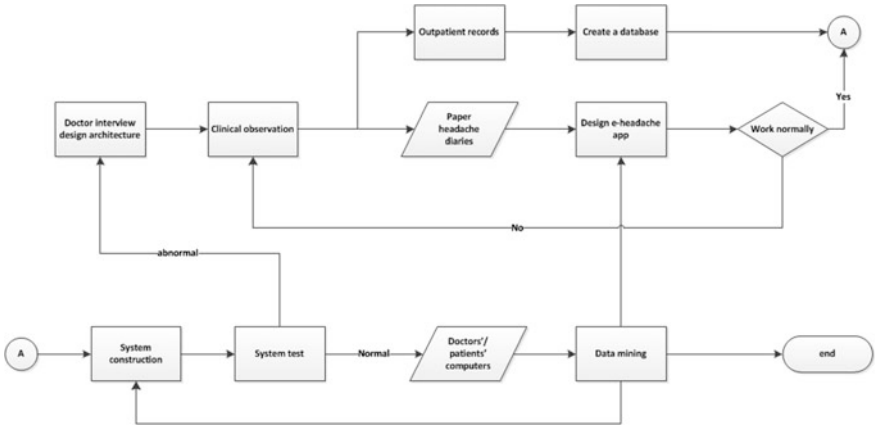

Fig. 2 Research steps

3.1 Research Steps

Figure 2 is the research steps of the study, in accordance with the steps to carry out and complete, to construct a clinical decision support system that can supply physicians with headache track and diagnosis of patients with migraine. Studies on Fig. 2 steps show as follows:

The Physician Interviews and Design Architecture

This research cooperation with a hospital in Taipei, the study focuses on the headache clinic neurology, in order to design the system's main structure, our clinicians discuss with neurology, to satisfy physicians' need to do system backbone, we also give advice to physician to determine whether to incorporate this recommendation system, after many meetings, we design a complete architecture diagram of the system. This research design the system architecture (Fig. 3), in terms of patients, patients use electronic headache diary to record his headache, and upload it to the database of our system, and the patients can download their dairy to their own smartphones; On examining the diary, patients can choose directly that watch diary over the mobile phone or from the front-end interface, this study will set the initial account as patient's id card number or medical record number, account shall be set by patients after login, the patients can see their record of the diaries that they uploaded to the system in the front-end interface. In terms of physician, the physician will have their own account and password, using the group account and password can enter the physician exclusive interface, physicians can enter a patient case number in the page or id number to bring up the headache diary, you can choose directly to examine the diary from the patient's action platform. The design of the system is aim to be simple and not complex, for the purpose of not only easy to use and can save time, is convenient for physicians and patients to review and examine the contents of the diaries.

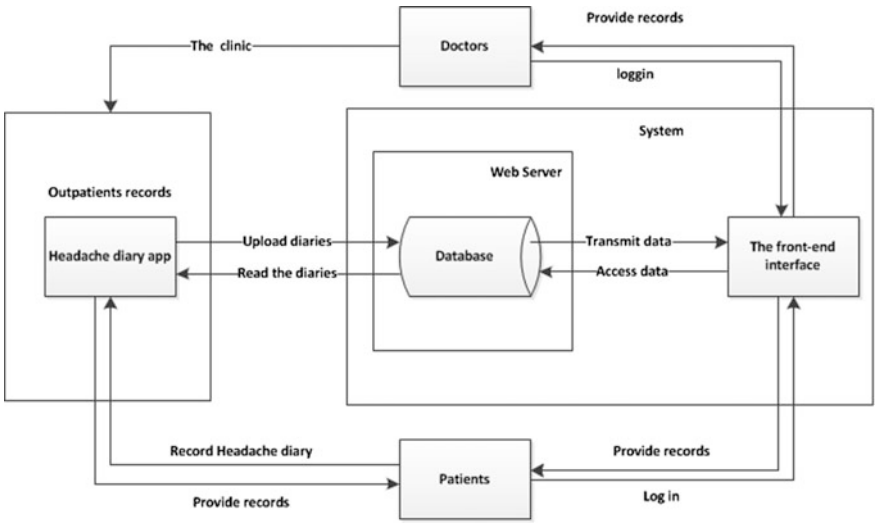

Fig. 3 System architecture

With Clinical and Observation

In order to improve the system accuracy, we will directly get into the outpatient service examines internal nerve headache clinic, to direct face-to-face contact patients with diagnosis way and detailed record the process of physician visits, to find out the advantages and disadvantages to be the reference of modification of the system. In the process of diagnosis, we can observe patients with migraine disease from time of the onset to find out what similarities or special relationship as a reference, moreover can also from a conversation with the patient to get some advice about the system and other ideas.

Design Electronic Headache Diary

In this study, we design the e-diary for Android, we use Android as a priority because Android is a free open source system, and it is suitable for use in testing the APP development stage, the development will meet some unexpected bugs, so it needs to test online and improve, and can use online test to get use suggestions, to improve and complete the application. When the Android App is done, we will design other version applications, such as IOS and Windows phone, to provide different mobile platform with the application; we will according to a paper diary as a reference provided by the hospital paper diaries ask the patients to record the projects: the degree of headache, symptoms of headache, omen of the headache, how many hours of headache, drug name and dosage, the effect of pain relievers, menstruation, etc., we will make development projects included in the above functions, in addition to design a function of statistic of headache situation can be used by the clinicians directly, this can help the doctors to know the condition of the

patients. System developers will go directly to a hospital in Taipei, help the patient install electronic headache diary and update version and we will transform the website that where can download the application into QR code, and stick it outside the clinic, teach the patients who are the first time to use the application how to use it correctly, and record the doctors' and patients' situation of using the application, etc., the patients who are the first time to install the application, we will ask them to leave their information to do the track of the system and contact the patients.

The Clinic Record

Because in this study we will go to a hospital in Taipei, we will record all the process and content of the clinical physician visits, for example: the question that the clinicians ask the patients, including patient's basic information, the patient's medical history, and the patient's family history, the drugs the patients take and the inspection of patients, the habit of life of patients and some other data, we will organize the data and transform it into files, for the follow-up data mining.

Set Up the Database

The database in this study is mainly used to store the data of the patients' headache diaries, the hospital can use the patients' migraine data to do further study. This study uses the relational database SQL Server, launched by the Microsoft, the database interface is simple and it is easy to operate. We will divide the data into five data table: user account data, personal data, the degree of headache, symptoms with the headache and drugs to match the e-headache diary. We used advanced programming Language like Java, ASP.NET, C#, and SQL Language for this part (Table 5).

System Construction

This study constructed the front-end user operation interface and back-end database for the system operation, the front-end user interface constructed the interface of website by web-based method, as most of the headaches associated with personal physique, the headache can be treated but is difficult to cure, according to clinical observation, migraine sufferers rarely pain for a lifetime, most major attack at the age of 15, 6 to 30 or 40 years old, when the age is 50 or 60 years old, the diseases will relief or disappear [13], in order to satisfy the age, we mainly design the system

Table 5 Data table

Data table name	Terms
User account data	ID, name, account, password
Personal data	Gender, birth, case number, job, marriage, the degree of education, phone number, address…
The degree of headache	Time, headache time(morning, noon, afternoon, night)
Symptoms with the headache	Concomitant symptom
Drugs	Date, drug name, dose, significant degree

for easy use and it will not bring other burdens on the patients, and the doctors and patients can easily get start in the application. We will use such as net platform and some other web-based to construct the system interface, such as web interface main settings: user login and registration, personal information, such as a headache diary shows.

System Testing

System of this research is mainly to assist physician to track the patients' headache situation, using electronic headache diary can reduce the trouble to carry, also can achieve the effect of immediately record and update, moreover physician can also use it to track the drugs of the patients, to provide physicians improve treatment method or replacing prescription drugs. After completion of the system construction, therefore, must pass a physician verification, to test if the system meets the needs of the doctors or not, whether can actually upload the situation of the patients, if we can't meet the requirements, we will return to the first step in with the physician to discuss again, review and find out the causes of the system construction of incorrect, and correct programs, repeat the step until complete our system.

Data Mining

In this study, we hope we can find out the factors lead to migraine in the record of the headache of the patients and the outpatient records, we will also use the tracking of the situation that the patients take medicine to do mining, to find out which kinds of drugs affect migraines, the effect is good or bad for migraine, whether to take some drugs can cause conflict or reduced, what types of patients and fit to eat what drugs, etc., we will also design the result of data mining into questions and add them to the system and e-headache diaries to improve the correct rate of the diagnosis of migraine.

4 Conclusion

This research will interview with the doctors, with the diagnosis and observation for a long time, complete the electronic version of the APP migraine headache diary and tracking system in the early time. And then on the academic and medical to construct a new system architecture clinical decision support system and organize huge amounts of data into database. And the contributions in medicine, including: this design can make use of the APP in the clinical medicine, and this app has a professional medical background; System can be used in clinical medicine; Can completely store and save for a long time headache patients data; Information can let a hospital to do more in-depth study of migraine.

When after the migraine tracking system finishes online using, provide the doctors to track and transform the patients' headache diaries into information, save the extra space and improve the service efficiency, we will sort and save the huge amounts of data that got from the patients, allow clinicians to save and view

patient's headaches data through the system, the patients' headache data shown in the system cam supply the doctors as the second reference of the diagnosis of migraine to improve accuracy of physicians' diagnosis of diseases, the doctors can also do the track of drugs from the data to provide physicians with the reference of improving treatment or replacing prescription drugs, in addition the hospital can also use this data to do more in-depth research and analysis of migraine, increase the understanding of the chronic migraine symptoms.

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