Modularization Medical Scheduling System for Multi-clinical Departments at Medical Center

Shu-Fang Cheng and Chia-Yeuan Han*

Abstract-A hospital is a place where sick patients are treated, treatments can be one-time, short-term, and long-term, such as chemotherapy and rehabilitation. The more patients who need to be treated; the more valuable medical resources become. With the increase of human population and the used of medical resources, how to effectively arrange medical resources has become the major problem faced by medical centers. However, different medical departments have different kinds of medical resources, and customizing the scheduling system for each department is not an effective approach. To solve this problem, we surveyed different medical departments in a (Medical Center in Southern Taiwan, summarize the needed, implemented a modularization Medical Scheduling System (MSS), for a Medical Center in Southern Taiwan, and resolve the complex appointment scheduling problem in a multi-clinic. The MSS improves work assignment effective and sensible utilization in medical device. Furthermore, it can be used for epidemic prevention and the control of Covid-19 pandemic. Based on the confirmed cases, we can identify potential contacts via MSS and contain the coronavirus.

Index Terms—Scheduling, appointment, medical center, Covid-19, multi-clinical

I. INTRODUCTION

Taiwan has a complete health care system that provides medical services including inpatient department, outpatient department, and emergency department. Hospitals take different various treatment methods and different treatment cycle for each patient, including one-time treatment, short-term treatment, and long-term treatment. Satisfaction has a positive impact on return visits, which shows that patients choose hospitals similar to how customers select their favorite stores [1], and excellent services improve customer satisfaction [2]. Therefore, healthcare professionals need to pay more attention on the planning of the treatment cycle for every single case and there is always a need to reschedule if needed. These departments, that provide the treatment cycle for patients will use some tools to record their appointment date, time, contact information, and expected treatment plan. The medical treatment process of each department is different, and customized systems are more suitable for experts [3]. But according to the statistics from the Statistics Department of the Ministry of Health and Welfare [4], there are more than 22 types of medical departments (Medicine and Traditional Chinese Medicine (TCM)), and each medical department has several of branches.

*Correspondence: hoganhan2@gmail.com (C.Y.H.)

Furthermore, each clinics/department has different appointment standards and treatment programs. Taking a Medical Center in Southern Taiwan as an example, there are seven different departments in this hospital, department of Internal Medical, Surgery, Pediatrics, Dentistry, Gynecology & Obstetrics, Traditional Chinese Medicine, and Other Department. The most known problem is long waiting time for treatment in the outpatient department [5]. For example, to lessen the waiting time for customers in dentistry means the reduction of dental chair usage time; but for another department is different, such as less examination waiting time is a major concern. Regardless of classification, the Medical Care Act states that information about patient's illnesses or health should not be posted on a hospital extranet [6].

To solve the above problems, this paper takes Medical Center in Southern Taiwan as an example and designs a modular multi-department shared Medical Scheduling System (MMS) to adapt the difference between departments' appointment standards. The system allows healthcare professionals to allocate human resources and equipment resources under the actual treatment conditions, allowing them to focus on the quality of medical services and patient safety.

II. INVESTIGATION

Through interviews and actual visits to the departments of Dentistry, Pediatrics, Cancer Center, Traditional Chinese Medicine, Urology, Nutrition & Health Education, Rehabilitation and Pharmacy of the medical center, we summarized each department's appointment method as following:

A. Dentistry Department

An annual physical appointment book is used to make appointments and each doctor has their own appointment book. When making an appointment, medical personnel would write down the scheduled time and patient's info on the book which is time consuming. The most common problems for using physical book are that it and the information recorded might be lost, defaced or scribbled, which is difficult to identify, and the limitation of writing spaces. Patients will receive a handwritten appointment card, in which they are required to bring back during the next visit. However, the appointment cards are often lost, thus more time are spent by medical personnel on screening through the appointment book.

B. Pediatrics Department

At the time of the survey, the appointment-based treatment included: "Attention-Deficit Hyperactivity Disorder (ADHD)", "Individual Psychotherapy", "Autism Attention

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The authors are with Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan.

Training", "Parent/Child Communication and Expression Improvement Course", etc. However, they do not use any tool to make appointments, so patients arriving early will be treated on a first-come, first-served basis, so there will be longer wait times when too many people arrived at the same time.

C. Cancer Center

Patients usually return to the center on fixed days (Monday, Wednesday, Friday or Tuesday, Thursday, Saturday, etc.) and most dialysis time are fixed (four hours, six hours, etc.). The center operates on a first-come, first-served basis, and only record bed occupancy. Most importantly they do not use any booking tools. Due to first-come-first-served basis and no valid tool for making arrangement, patient often spend too much time on pending empty bed. Therefore, cancer center needs a bed reservation system.

D. Traditional Chinese Medicine Department (TCM)

TCM treatment includes "Acupuncture" and "Laser Acupuncture". They do not have any arrangement tools and patients are treated on a first-come, first-served basis. Therefore, TCM hopes to build an appointment system for "Laser Acupuncture", "Acupuncture Point Thread Embedding Therapy" and "Facial Acupuncture". Thus, limiting the number of patients at the same time, and improved equipment utilization and treatment efficiency.

E. Urology Department

Since this department doesn't have any appointment system for Electrical Stimulation, there is no way to know how many patients will come or how many treatments need to be done in a day. So, an electrical stimulation appointment system for Urology Department is the desired design. The system will have a verify function, which show a warning message or block the appointed time slot if the desire time is taken. The department will also implement a new process called "check-in to treat". Each patient will receive an appointment paper, which includes precaution and scheduling information, after booking. Which means the patient will to need to follow the time slot, check-in first, and then receive treatment. Overall, this department needs a system to provide a function that can set the maximum number of patients per day, which varies day to day.

F. Nutrition & Health Education Department

By handling inpatient and outpatient consultations, nutritionist can provide proper nutritional assessment or reassessment, which helps healthcare provider to identify patient's nutritional status. When an assessment is required, the nutrition department will receive a call and the medical personnel will lead the patient to the department. If there's an appointment system for this department, medical personnel can help patient schedule an appointment with a professional dietitian. Moreover, they can classify patients into inpatient, outpatient or reassessment patient and summarize the total number of finished cases or tracking patients.

G. Rehabilitation Department

There are many treatment options in this department, most are continuous. However, the method they use for handling

appointments is by giving patient a small record card that display total number of treatments and how many treatments are remaining. Medical personnel are responsible for scheduling the therapist's daily schedule and patient appointment through Excel. Therefore, if the department needs to calculate the type of daily appointments (physical therapy, occupational therapy, speech therapy, etc.) or the expected number of treatments per therapist, they will have to do it manually.

According to the above problems, the Rehabilitation Department hopes to implement an appointment system that therapists can arrange daily patients and their treatment. It can dynamically schedule multiple treatments at once to simplify the appointment process. In addition, by adding the following management features: patient's treatment status panel, print out appointment scheduling paper, closed time management and statistical report can allow this department to establish a standardized management mechanism for the appointment scheduling system.

H. Pharmacy Department

One of the services of the Pharmacy Department is patient enrollment and follow-up who fulfill the criteria of the "Pre-end-stage renal disease (Pre-ESRD) Project". The pharmacy department needs an appointment system to schedule patients for Pre-ESRD. Due to the project acceptance and return visit date restrictions, the system needs to track the patient's return date, treatment status, and provided digital signature.

III. System Architecture

After research and collective analysis, from various departments, we summarize the system architecture as shown in Fig. 1. The MSS is divided into three parts, as described below:



Fig. 1. Medical scheduling System, MSS - system architecture.

A. Design Layer

Designs include User Interface / User Experience (UI/UX) of each department, data preprocessing and Responsive Web Design (RWD) to automatically adjust for different screen size and end device.

B. Service Layer

This part handles the Windows Communication Foundation (WCF) and Application Programming Interface (API) communication services of the system and separate front-end and back-end servers.

C. Logic Layer

This layer handles custom rules of each department, such as validation (for example: checking repeated appointment, limiting the number of daily patients, rejecting appointments with specific rules, etc.), statistical data processing and other functions.

The design layer shown in Fig. 2 is subdivided into Appointment Scheduling Module, Viewer Module and Management Module, which are described as follows:



Fig. 2. Medical Scheduling System, MSS - design layer.

1) Appointment scheduling module

a) Date, time

Records the date and time of treatment. Data fields can be typed freely and provide customized shortcut options for each department to simplify the appointment process; or use adaptive filling (for example: a treatment time is fixed at 30 minutes; the system will automatically fill in the end time by 30 minutes).

b) Patient profiles

After entering the patient's ID number or medical record number, the system will automatically display patient's name, date of birth, age, gender, and contact number, which is useful for patient identification and easier for medical personnel to contact patient.

c) Category

The appointment or treatment that patient has booked. Each department can have custom categories, such as devices, treatment sets, treatment types or healthcare professionals (for example: can be set to medical devices, physicians or therapist). Categories can also be grouped if needed.

d) Memo

Records any messages that are important to per say appointment and also has custom shortcut options to simplify the appointment process.

e) Extended feature

Handles custom functions for each department. For example: Nutrition & Health Education Department can classify which department does the patient comes from (inpatient or outpatient, and record the department information); Cancer Center can track patient registration status; Dentistry Department can arrange which chair the patient should sit in.

2) Viewer module

a) Calendar multi-viewer

The schedule can be viewed according to the specified date range, and there are four modes to view: monthly, weekly, daily and schedule list. Each appointment event can read the contents recorded in Appointment Scheduling Module.

b) Categories and groups

By switching categories or groups, different booking information can be presented. For example, Dentistry Department can display a list of doctor's appointment for the day, or the status of the treatment chair usage. Each department can define its own categories and groups.

c) Print

Print the schedule events displayed on the screen, including monthly, weekly, and daily or schedule list. Each category will be separated by a different color, and details of each event will be listed.

3) Management module

a) Category setting/grouping setting

Each department can manage its own category to classify the appointments and group them if needed. This function helps with viewing when the schedule is displayed. It can be set up and adjusted at any time, whether it's a device replacement or temporary support from doctors.

b) Quick-memo setting

Each department can customize their shortcut options for memo to speed up the appointment process. It can be set to common statement, precautions, or any notes.

c) Extended feature settings

Manage extended functions, such as setting the maximum number of schedule per day, setting available appointment times or turning on/off system functions.

d) Authority management

Authorizing the system or system's functions, such as controlling who can access MSS in which department or which features are available to specific people.

IV. RESULT

This paper implements MSS in Medical Center in Southern Taiwan. After several days of operation in Dentistry, Pediatrics, Cancer Center, Traditional Chinese Medicine, Urology, Nutrition & Health Education, Rehabilitation and Pharmacy department, the statistics are summarized as follows.

After collecting data on about 900 appointments in various departments, we received the following results. The average time for adding a new appointment is 40.34 seconds, the fastest is 26.12 seconds from the Pharmacy Department, and the slowest is 69.45 seconds from the Cancer Center (Fig. 3). The average time for search and modify appointment is 36.82, Nutrition & Health Education Department is the fastest one which only takes 25.50 seconds to finish and Dentistry Department is the slowest which takes up to 50.99 seconds to complete the process (Fig. 4). This indicates that on average it only takes 1 minute to make an appointment.



Fig. 3. Average appointment time (seconds).



Fig. 4. Average search and modify time (seconds).

The patient attendance rate (percentage of patients who attended as scheduled) has improved significantly after using MSS. By comparing data between 2018 and 2021, patient attendance rate has increased every month with highest growth rate of 5.56% (Fig. 5).

Since MSS has records of occupy date, time, use of medical devices, etc., it can be used for contact tracing. For example, during the Covid-19 pandemic, one of the Taiwan's precautions is to quarantine contacts. After cross-comparing the MSS data with hospital medical records, high-risk contacts will be listed and quarantine to prevent the spread of the coronavirus (Fig. 6).



Fig. 5. Attendance rate.



V. CONCLUSION

In this paper, a Medical Scheduling System (MSS) is implemented for multi-clinical departments of a hospital. In addition to provide appointments, each department can adjust the system mode and extended features by themselves. For example: tracking patient registration status, arrange chairs for patients can sit in, statistics reports and digital signatures. During the Covid-19 pandemic, medical personnel use MSS system to trace up patient, who might be potential carrier or had contacted with the carrier, and knowing which medical devices has been used. This paper provides an efficient appointment method and a simple management module to improve the allocation of human resources and medical device utilization rate in medical institutions, and solve the complex appointment problems of different medical departments.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Shu-Fang Cheng and Chia-Yeuan Han wrote the paper; all authors had approved the final version.

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