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Design an automatic appointment system to improve patient access to primary health care

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Abstract
Advanced Access model has been introduced in general practice in the United States to improve patient access to primary health care services for more than ten years. It has brought in the benefits of eliminating service provider's waiting lists, improving patients' timely access to services and reducing no-show rate. However, to implement this model, practices need to collect relevant information, develop contingency plans and set up practice strategies to balance the provision of care and patient's demand. These tasks are not always easy to achieve. Understanding the requirements and constraints for effective management of patient booking is essential for developing an automatic appointment system that effectively supports this model in practice. This paper discussed these requirements and constraints, and then proposed a new model for automatic information collection, real time service monitoring and rule-based appointment decision making to balance demand and supply.

Keywords
care, design, appointment, automatic, system, improve, patient, access, primary, health

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ABSTRACT
Advanced Access model has been introduced in general practice in the United States to improve patient access to primary health care services for more than ten years. It has brought in the benefits of eliminating service provider’s waiting lists, improving patients’ timely access to services and reducing no-show rate. However, to implement this model, practices need to collect relevant information, develop contingency plans and set up practice strategies to balance the provision of care and patient’s demand. These tasks are not always easy to achieve. Understanding the requirements and constraints for effective management of patient booking is essential for developing an automatic appointment system that effectively supports this model in practice. This paper discussed these requirements and constraints, and then proposed a new model for automatic information collection, real time service monitoring and rule-based appointment decision making to balance demand and supply.

Keywords
Advanced Access, appointment system, patient access, primary health care

1. INTRODUCTION
In Australia, medical practitioners are distributed unevenly across the country that the practitioners in remote areas are 40% shortage compared with the average level in the country [1]. However, in some remote areas, such as Great Western and Southern of New South Wales, this ratio could only reach 1/8 of the average level [2]. Thus, patients always find it difficult with accessing to health care services in these areas. For example, a study in Wagga Wagga finds that a patient could wait up to 55 days for a routine appointment to see a General Practitioner (GP) [3].

Despite the shortage of workforce, one of the main reasons for this difficulty is that the way practice takes appointments (appointment model) mainly accounts providers’ static schedule. For example, once a GP’s schedule on a specific day has been fixed, patient appointment is arranged in the carved out slots. If patients’ demands on that day exceed the provider’s supply within the scheduled time, then the exceeded demands will be postponed into the future schedule, which cause service delay. As time goes on, the postponed appointments form a long list of backlog, which seriously impedes patients’ access to health care services. Previous studies indicate that service delay occurred more frequently when patients experience long time waiting [3-5], which wastes the precious GP’s time slot allocated to this patient. It also blocks another patient’s access to the services. In the long run, the recurrent occurrence of this situation will eventually cause the deterioration of the supply of health care services [6, 7].

A new appointment model entitled Advanced Access (AA) was proposed by Murray and Tantau [8] to balance supply and demand, and diminish backlog of appointments and delay of primary health care services. According to the AA model, practices are required to provide same-day service when a patient requests an appointment. The Advanced Access model proposes to achieve this goal through the implementation of six strategies: “balancing supply and demand, reducing backlog, reducing the variety of appointment types, developing contingency plans for unusual circumstances, working to adjust demand profiles, and increasing the availability of bottleneck resources”. Direct benefits of Advanced Access include significant improvement in patient accessibility [3, 9-11] and the reduction of patients’ no-show rates [3, 4, 9].

To date, the AA model is the best primary health care management model in terms of providing timely services to patients [7]. It is promoted in England by the National Primary Care Development Team as a way of improving access and achieving National Health Service (NHS) planned access targets. Studies indicate that 67% of practices in England claimed to operate Advanced Access [10]. Australian Primary Care Collaborative (APCC) has established its phase 2 program in December 2007, and one of the topics is to improve patient access to primary care [12]. Two empirical studies carried out by Dr Knight suggest that this model could work effectively in Australia as well [3]. Therefore we propose to develop an automated appointment system that is underpinned by the theory of the AA model.

As indicated above, the initiative of AA was well accepted in USA, UK and other countries. However implementing this model poses many new challenges to primary health care services. It requires shifting the criteria for appointment decision making from provider’s schedule to patient’s demand [13, 14]. The huge effort to manage the demand and supply leads to complex changes not only reflecting on the accessibility and no-show rates, but also continuity of care, providers’ workload and practice working...
The balance between demand and supply.

patient's demand; (2) manage provider's supply, and (3) maintain care services, the AAS needs to have the capability to: (1) trace Therefore, in order to improve patient's access to primary health education and reference materials [7].

chronic disease, providing patients and families with home-care extending the intervals between return visits for patients with do follow-up care, developing group medicinal visits and or e-mail instead of visits to respond to patients' questions and to problem of shortage of medical staff, such as using the telephone or e-mail instead of visits to respond to patients' questions and to adapt an 'alternative method' to solve the problem of shortage of medical staff members [18]. To balance demand and request, AAS can use 'straight method' to To balance demand and request, AAS can use 'straight method' to solve the temporary burst of demand by increasing service providers' workload; or adopt an 'alternative method' to solve the problem of shortage of medical staff, such as using the telephone or e-mail instead of visits to respond to patients' questions and to do follow-up care, developing group medicinal visits and extending the intervals between return visits for patients with chronic disease, providing patients and families with home-care education and reference materials [7]. Therefore, in order to improve patient's access to primary health care services, the AAS needs to have the capability to: (1) trace patient's demand; (2) manage provider's supply, and (3) maintain the balance between demand and supply.

3. System Design

Our proposed Advanced Appointment System is composed of six elements (Figure 1): a System Interface, a Data Repository, a Request module, a Performance module, a Strategy module and a Scheduling module. The Interface provides functionalities to exchange information with end users. The Data Repository is used to store all the relevant data that are used. The four modules are the core component in this design. The Request module is used to calculate patients' demand by tracing patients' everyday requests and sorting these requests in different categories. Basically, patient requests are entered by users from the System Interface; the Request module classifies these requests and stores them in the Data Repository. If a request already exists in the Data Repository, the module can retrieve this request and display it onto the System Interface. The Performance module checks the practice performance based on the extent of satisfaction of the demand. If the satisfaction level is below a defined threshold, the Performance module will trigger the Strategy module to adjust the strategy for patient appointment. Activated by the Performance module, the Strategy module will provide recommendations to assist a user to manually make appointments in light of the need of equalising demand and supply. The Scheduling module is used to dynamically manage provider's workload, arrange patient requests with appointments and display provider's schedule.

2. Requirements Analysis

Tantau suggests that the three foundational elements for the success and sustainability of the Advanced Access model are capacity, continuity, and demand and supply equilibrium [9]. We will implement these elements in the AAS. Capacity is measured by the providers’ working hours. Continuity is an important attribute to decide the quality of care, and can be traced by recording whether a patient is assigned to the appointed provider. There are many methods to balance demand and supply. The primary objective of balancing demand and supply is to guarantee the patient's accessibility to health care services. Accessibility can be measured by the ratio of patients' demands that have been fulfilled and the waiting time from initiation of a patient’s request to the fulfillment of this request.

The problem of balancing demand and request is that although patient demand for services is predictable to a certain extent, it is not always accurate. This requires providers to accurately record patients’ requests and plans the provision of care services accordingly. Imbalanced demand and supply may be caused by fluctuation of demand or shortage of medical staff members [18]. To balance demand and request, AAS can use 'straight method' to solve the temporary burst of demand by increasing service providers’ workload; or adapt an ‘alternative method’ to solve the problem of shortage of medical staff, such as using the telephone or e-mail instead of visits to respond to patients’ questions and to do follow-up care, developing group medicinal visits and extending the intervals between return visits for patients with chronic disease, providing patients and families with home-care education and reference materials [7].

Therefore, in order to improve patient’s access to primary health care services, the AAS needs to have the capability to: (1) trace patient’s demand; (2) manage provider’s supply, and (3) maintain the balance between demand and supply.

The following sections detail the functions of each module.

3.1 Request module

The Request module is used to calculate the number of patient demands by tracing the processing of a patient’s request in three states: booked appointment, pending request and discarded request (see Figure 2). There are three reasons for tracing these requests: First, to satisfy Advanced Access model, a practice aims to satisfy each patient’s request for an appointment on the day they want it. Tracing each patient’s request can help the practice to find the real demand for each service provider on a daily basis. Second, recoding the patient’ demand into different patient categories can help the practice to estimate the types and number of services needed by patients. Third, finding out the ratio of
demands that have been fulfilled can enable the practice to understand the gap between demand and supply.

For example, Dr. Lightman can serve 30 patients per day, but he does not take pre-scheduled appointments. There is a burst of influenza and 45 patients need to see Dr. Lightman on one day. Obviously there would be 15 patients who could not see this GP.

The demand for the next day’s service from Dr. Lightman is 45 patients. Does it mean that the demand for Dr Lightman is now 45 patients per day? The answer is ‘No. The patients come to see Dr. Lightman may include the patients who did not get the opportunity to see him the previous day, besides the patients that he sees regularly and some new patients. In order to accurately assess the patient demand for Dr. Lightman, we need to classify his patient request into three states: (1) booked appointment if the patient is offered an appointment; (2) pending request (or unsatisfied request), a middle state, if the patient is not offered an appointment, but wish to call back to fulfill this request; and (3) discarded request if the patient gives up this request. Figure 2 describes these three patient request states and the relationships amongst them for seeing Dr. Lightman on a day.

Figure 2: The three states of a patient’s request for seeing Dr. Lightman and the transaction processes amongst the three states.

This formulate notates that fulfilled demand on a specific day equals to all the appointments booked on that day minus the number of appointments given to the pending requests.

3.2 Schedule module

Recoding patients’ daily demand helps to estimate future supply; however, the estimated supply may not match the true demand on a particular day. If the estimated demand is lower than the actual demand, then extra capacity of supply needs to be established to match the demand [19]. In the example above, it is desirable to put in extra capacity to be in place to match the 15 extra demands for Doctor Lightman on that particular day. Although it is possible to put in extra capacity to handle the increasing demand, there is a constant worry that demand is infinite [17]; therefore, we propose a Schedule model to address this challenge. The Schedule module should sort provider’s capacity into two categories: standard capacity and potential capacity. Standard capacity refers to the consultation that the providers can supply within their standard working session. Potential capacity is the quantity of consultation supplied on providers’ extra time. By default the potential capacity is not displayed on a provider’s schedule, but they are available when there is a shortage of supply. The reservation of the potential capacity is important for a practice to maintain the balance between demand and supply on a daily basis. This can reduce the backlog in the short term but may increase the workload of service suppliers. The size of a provider’s capacity is managed by Schedule module; however, how this capacity is decided is supported by the rules from the Strategy module once been triggered by the Performance module (see Figure 1) and approved by an end user.

3.3 Performance module

The Performance module monitors the service’s performance in a practice. The performance is measured according to the three targets of Advanced Access model: increasing accessibility and for patients, guarantee continuity of care for patient and balancing workload for service providers, as mentioned in the introduction section. Different practices have different requirements on service accessibility (e.g. same-day access or 48-hours access) [20, 21] and continuity (individual continuity or group continuity) [22] and flexibility on workload [14]. This requires the practice to set up the boundaries and thresholds for each of these attributes. Once these practice “rules” are determined the Performance module will be able to effectively execute its function of monitoring the performance of a practice and sending alarms to the system when the rules and standards of performance are violated.

3.4 Strategy module

To help with appointment decision making, the AAS incorporates a Strategy module to store all of the relevant rules for managing patient appointments. Once triggered by the signal sent from the Performance module, a relevant rule-based recommendation will be presented to an end user to facilitate the person to make the relevant appointment decisions. Currently 13 rules to be used in practice [3, 4, 18, 23–25] have been gathered and would be placed in our Strategy module, as listed below:
1. Increase Provider Workload (use optional hours) (IPW(H)): Providers provide small size extra capacity by using optional hours.

2. Increase Provider Workload (use extra sessions) (IPW(S)): Providers provide large size extra capacity by using extra sessions.

3. Restrict New Patient (RNP): Providers refuse new patients added to their panel to reduce patients’ demands.

4. Restrict Prescheduled Appointment (RPA): Providers restrict prescheduled appointments on certain days for certain people to provide sufficient capacity on the specific day. This method is commonly used when practice try to shift the prescheduled appointment from certain heavy duty day, such as the day after holiday.

5. Deny Prescheduled Appointment (DPA): practice restricts the number of days that patients can make pre-booked appointments. This may reduce the number of missed appointments and improve capacity available for patient, however may sacrifice some convenience for same patients such as aged people.

6. Increase provider standard session (IPSS): increase a provider’s standard work session, so that this provider’s routine capacity will be increased, such as some of part-time providers changed to full-time during implementation of AA.

7. Recruit a Temporary Physician (RTP): organisation recruits a provider to temporarily increase the health care supply. It temporarily improves the capacity to work down backlogs or to fill the capacity gap when a provider is on holidays.

8. Recruit a Physician (RP): practice recruits a provider to increase the health care supply for long term to improve long term capacity.

9. Assign Roles to Practice Nurse (ARPN): practice assign practice nurses to deal with certain cases. In this way, the provision can be increased for long term. Nurses can be potential alternatives to improve access to diabetes care in settings where physicians are not available [26].

10. Group Consultation (GC): Provider provides consultation to a group of people at the same time. In this way, this provider could improve healthcare supply.

11. Telephone Consultation (TC): provider provides telephone consultation to patients. In this way, the appointment interval can be reduced , It is not applicable for Medicare claim.

12. Shift Demand to Other Providers (SDOP): practice shifts patients from high workload providers to low workload providers.

13. Appointment Redesign (AR): practice redesigns the appointment types and intervals to increase the supply, such as evidence based practice to decide patient follow-up interval.

These strategies have been organised at three levels based on the length of effects and complexity of implementation: Day-to-Day Administration level, Practice Administration level, and Service Administration level (In Figure 3), so that they can be invoked in different states. IPW(H), IPW(S), SDOP and RNP work at the Day-to-Day Administration level, because these rules are always used when a patient calls in to balance daily fluctuation of demands, and have short-term impact on balancing demand and supply. IPSS, RTP and RP work at the Practice Administration level that relays on the leadership to introduce new staff member into the practice, which result in the growth of supply in the long term. Strategies at this level will be suggested to work out the backlogs that providers could deal with, such as when a provider has left. The rest of the rules work at the Service Administration level, because GC and TC change the way that primary health care is provided to a patient; RPA, DPA and AR decide the way to take appointment; and ARPN changes the providers’ structure. All of these rules at Service Administration level will have profound effects on the provision of care.

4. System Process

After explaining the functionalities provided by each model of the AAS, the next step is to design the work flow of the AAS to support Advanced Access. The proposed process of using the AAS to make an appointment for a patient includes three phases as shown in Figure 4.

![Figure 4: The process of arranging an appointment using advanced appointment system](image-url)
4.1 Phase 1: Registering Request

Figure 5: Phase 1, Record patient request

In phase 1 (See Figure 5), a receptionist receives a request from a patient and inputs this request to the appointment system. The appointment system checks the type of this request. If this request comes from a pending request in the system, the system will pick up this pending request; otherwise, it will register a new request into the system.

4.2 Phase 2: Checking Strategies

After registering patient request, the appointment system checks the performance of this type of service, which consists of three attributes: accessibility, continuity and workload. If the system performance remains at the acceptable level, the system will execute according to the default strategy. If the Performance module identifies abnormal performance, it will trigger a corresponding alarm in accordance with the relevant rules in its rules database, which is managed by Strategy module. This will alert an end user to implement the relevant strategy to improve the service performance (Figure 6).

Figure 6: Phase 2, Check Strategies

As mentioned in Section 2.4, we have identified 13 rules that may affect the provision of care for a patient at three levels and from short term to long term. If the declination of service performance is caused by the fluctuation of request or demand, the system will provide Appointment Administration level rules. If the declination of service performance is caused by the shortage of supply, the system will not only provide Appointment Administration level rules to temporarily balance demand and supply, but also higher level rules to radically improve the service supply. The Appointment Administration level rules IPW(H) and IPW(S) can both provide extra capacity of supply but may increase a provider’s workload. SDOP could increase the provider’s capacity but affects the continuity of care as the patient is allocated to another provider (not group continuity); RNP can balance the request and demand with no effect on the existing patients and providers, but it decreases patient’s accessibility to service. Therefore the selection of these strategies will be based on the priorities of the practice whether they prefer to privilege accessibility, continuity or workload.

4.3 Phase 3: Arrange Appointment

In phase 3, a receptionist follows the selected rules to arrange an appointment for a patient. If the patient is satisfied with the appointment, then the patient’s demand has been fulfilled and the request turns to booked appointment. For any other reasons that the appointment is not booked, the system will postpone this request, and this request becomes a pending request.

Figure 7: Phase 3, Arrange Appointment

5. Conclusions and Future Work

The Advanced Appointment System proposed in this paper presents an innovative solution to resolving the challenges for patients to access primary health care services. The mechanism for AAS to improve patient appointment process in primary health care includes: (1) revealing patient demand by steadily tracing patients’ requests during the whole appointment process; (2) providing a performance triggered process to sustain the provision of care; and (3) structuring the practice rules to balance demand and supply under different circumstances. The fundamental work in this study, such as workflow analysis, has been taken in Centre Health Complex (CHC) in Shellharbour. In the future, a rigorous validation of the data model of AAS is required to validate the design of the AAS. An algorithm for the Performance module should be established to accurately trigger the implementation of
the right practice strategy based on the culture of Australian General Practice. Meanwhile, the pilot software of AAS is planned to be implemented in CHC for GP sectors and Allied Health Sectors, as a core component of integrated appointment system project.

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REFERENCES