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Abstract

Doctors in a teaching hospital perform a variety of teaching, research, seminar, and in-patient care activities in addition to managing outpatient volumes. In this paper, we study the weekly activities of a doctor in a large teaching hospital in southern India, where the doctor's daily work load has grown primarily due to large patient volumes (during the year 2010-11, the hospital handled a daily load of 5,000 outpatients, 2,000 inpatients, and 125 surgeries) and large student intake per year (about 2000 students in various health disciplines). Ineffective doctor activities plan often resulted in missed activities, long patient duration of stay (3 days between successive visits), long doctor hospital hours (more than 10 hours per day), and low patient satisfaction levels. We propose alternate plans for doctors' activities without compromising their involvement in other activities and maintaining the same quality of patient service. The period of stay of the out-patients as well as doctors hospital hours are reduced substantially, mutually benefiting both the hospital and the patients.

Planning the Activities of Doctors in a Teaching Hospital

1. Introduction

Dr Ida Scudder founded the Christian Medical College (CMC) Hospital, Vellore after she returned to India following her graduation from Cornell University Medical College, USA. The medical school which she established in 1918 as a medical college for women with a Licensed Medical Practitioner course became a full-fledged medical college offering MBBS degree for men and women in 1947.

By 2011, CMC had become a centre of excellence in medical and health education, with over 150 different post graduate courses in medical, nursing, and allied health disciplines in which nearly 2,000 students were enrolled. The hospital provides more than 2,500 beds distributed over a number of campuses with 42 different clinics, each covering a number of specialities with sufficient availability of up-to-date investigation facilities. The CMC Hospital with a dedicated staff of over 8,000 which included 1300 doctors and 2,500 nurses is involved in (i) patient care, (ii) teaching and training, and (iii) research activities. During the year 2010-11, the hospital handled a daily load of 5,000 outpatients, 2,000 inpatients, 25,000 laboratory tests, 1,500 radiology investigations, and 125 surgeries. In the same year, its teaching and training activities produced 60 MBBS doctors, 99 Post graduate medical degree and diploma holders, 240 nurses, and 243 allied medical and health professionals. Its research efforts led to 230 publications in academic journals, 270 internal research proposals, and 108 external proposals.

Medical Council of India (MCI), the regulatory body for medical education in India, has laid down minimum standard requirements for medical colleges offering Under Graduate (UG) programme, and Post Graduate (PG) degree/diploma programmes. Each medical college is organized into clinical and non-clinical departments. The UG program, MBBS, starts with non-clinical teaching (such as anatomy and physiology) in the first 18-24 months, followed by clinical teaching and practical training.

Each clinical department is divided into 'Units' for administrative convenience. The number of beds per unit and the minimum staff strength per unit for offering UG and PG programs are clearly laid down by MCI. Each clinical department is expected to

(i) provide patient care (outpatient and inpatient care) and outreach services,
(ii) offer teaching under graduate MBBS program and post graduate diploma and degree programs MD/MS, DM/M Ch , and
(iii) excel in research contributions through publications in international journals.

Beginning the academic year 2013-14, CMC has decided to increase its annual intake for the MBBS program from 60 to 100 students. The annual admissions for its PG programs also would be doubled following a Government of India decision to double the number of PG seats in all medical colleges. The increasing demand for patient care, both out-patient and in-patient services, is likely to continue. CMC management is therefore concerned about the increased load on its doctors for patient care, teaching and research activities, and is keen to develop a plan of activities for its doctors so that they can continue to engage in patient care, teaching and research activities effectively and efficiently.

In the next section we discuss the load on teaching, research and patient care of doctors in the medicine department, for illustration. We have chosen medicine department, since it handles the largest number of out-patients and inpatients among all clinical departments at CMC Hospital.

2. Doctors' Activities: Medicine Department

The department of general medicine is one of the busiest departments at the hospital. It has a staff composition of 24 faculty, 32 postgraduate students, and about 100 nurses. Faculty members who are Professors and Associate professors are also known as senior consultants, while the Assistant Professors are known as Junior consultants. PG students are called Registrars and Senior/Junior residents.

The weekly activities of a doctor in the general medicine department include the following:

2.1 OPD Consultation:

Each unit has two OPD days from 8.00 AM to 5.00 PM. The total OPD load is around 300-350 general patients and 100-150 private patients per day. Private patients are those who are given appointments for consultation with their chosen doctor and are therefore charged considerably higher consultation fee than the general patients who are seen by any doctor present in the OPD.

2.2 Inpatient Care:

Inpatient care at CMC Vellore consists of split rounds and grand rounds

Split Rounds: Each unit has 40 general beds and 10-15 private patients. Each unit is divided into three teams, each of which looks after their male, female and private patients separately. Each team has one consultant, one or more PG registrars and one or more interns. Each team does morning and evening rounds every day. The consultant conducts the morning rounds while the PG registrar does the evening rounds. These rounds are known as split rounds, because the unit is split into three teams.

Grand Round: In grand rounds, the entire unit visits all its patients as a single team. Grand rounds offer excellent opportunities for the MBBS students to review many more cases and thereby add immense value to teaching and decision making in relation to complex cases.

Ward Work: Ward work includes patients who are admitted for investigations, seriously ill patients in emergency, Intensive Care Unit (ICU) or semi-ICU. Interns, PGs and faculty take care of the patients on hour-to-hour and day-to-day basis from admission to discharge along with other team members (nurses, physiotherapist etc). The registrars along with their interns ensure that their patients' medical needs are well taken care of, and proper documentations are maintained. Usually, ward work and procedures reach their peak after the grand and split rounds, when fresh investigations and/or medicines are ordered. During the initial admission, the focus is on history, examination, and ordering investigations. In the middle phase, focus shifts to further investigation, assessing the progress of treatment, and on-going analysis of the problem. In the last phase, ward activities focus on preparation of the discharge summary,

explaining the disease and treatment to the patient and family, followed by planning for discharge.

2.3 *Outreach Services*:

Units are encouraged to undertake outreach activities such as clinical work in secondary care hospitals or linkage to mission hospitals including telemedicine link, visits to mission hospitals, faculty exchange, joint projects etc. The objective of introducing these services is to expose the students to the health care needs of the rural population.

2.4 *Teaching:*

UG Teaching*:* UG teaching involves formal classroom teaching as well as bed-side teaching during OPD consultation and ward visits (Split rounds and Grand rounds). Undergraduate clinics are conducted every day in the morning, Monday through Saturday. Formal classroom theoretical lectures are usually scheduled in the afternoons.

PG Teaching: PG teaching also involves formal classroom teaching and bed-side teachings. Formal classroom theoretical lectures are scheduled only in the afternoons. PG students also take part in academic meetings, such as journal clubs, seminars, clinical meeting presentations, etc.

Table 1 gives the teaching staff composition for UG and PG teaching in the department of general medicine. Table 2 gives the teaching load for a medicine unit.

Table 1: Teaching Staff Composition for UG and PG teaching (Department of General Medicine), Source: Hospital Records

Doctors	Unit 1	Unit 2	Unit 3	Unit 4	Total
Professors	3	1	2	1	7
Associate Professors	1	2	2	2	7
Assistant Professors	3	3	3	3	12
Senior Residents	1	1	1	1	4
Jr Residents	6	6	6	6	24
Any others (Interns??)	5	5	5	5	20
Total	19	18	19	18	74

Doctors teaching counted in both UG and PG.

Table 2: MBBS Teaching Load for a Medicine Unit, Source: Hospital Records

Unit	Year	Classroom teaching Hours/week	Bed side teaching Hours/week
Unit 1	Year 2 (10 weeks)	6	12
	Year 3 (4 weeks whole day)	6	22
	Year 4 (6 weeks whole day and 4 weeks half day)	12	Whole day-22 Half day-12

2.5 ***Academic Meetings:***

Academic meetings include journal club, seminar, special sessions, and death audit. Journal club meet once a week usually in the morning, where a journal article is presented by a PG student and discussed jointly by the entire unit. Weekly seminars are held every week where a PG student makes a detailed presentation on a particular topic. Clinical meetings are held once a week, where PGs present interesting cases. This is s a forum for much debate and discussion. Once in a month Clinico-pathologic conferences are held, which are very popular for challenging teaching exercise.

2.6 ***Death Audit:***

All death cases over the previous one month are discussed in detail focussing on lessons, errors both of omission and commission. The reports are sent to the Medical Superintendent's office.

2.7 ***Research:***

Research is an essential component of a faculty member's work. Faculty members have to undergo research methodology and research ethics workshop. Faculty also supervise PG thesis (two per Professor and one per Associate Professor). Each unit has special areas of clinical work (example Infectious Disease and Clinical Toxicology for Medicine Unit I, Clinical Epidemiology for Medicine Unit II). The research outputs help in improving the quality of patient care. Each faculty member presents research papers at one to two research conferences every year.

2.8 ***External Examiners:***

Every year, about three to four faculty members are external examiners in theory and practical examinations in UG and PG courses. This is considered a part of teaching activity.

2.9 ***Administration:***

The unit head is in-charge of all the unit clinical activities, such as (OPD, inpatient, emergency), teaching activities (UG and PG)), research, faculty development, financial

aspects, and office work. The Head of Department coordinates across all the units in relation to clinical work, training, and research.

Table 3 summarises the estimated weekly load of a doctor in the department of general medicine.

3. The Current Schedule

As discussed earlier, among all the departments in CMCH, the medicine department is one of the busiest departments and serves a large number of patients. It comprises of 24 doctors, 32 post graduate students, and around 100 nurses. The department is divided into four units: Medicine unit I, II, III, and IV. The fourth unit is a specialty unit and caters to patients with infectious diseases and is not involved with OPD. Each unit consists of 4 consultants, 4 or more Registrars and 4 or more Interns. The professors and the associate professors are called Senior Consultant; the assistant professor is called Junior Consultant. The PG students are called Registrar or Junior Residents while those who have completed their PG and not teaching currently are called Senior Residents.

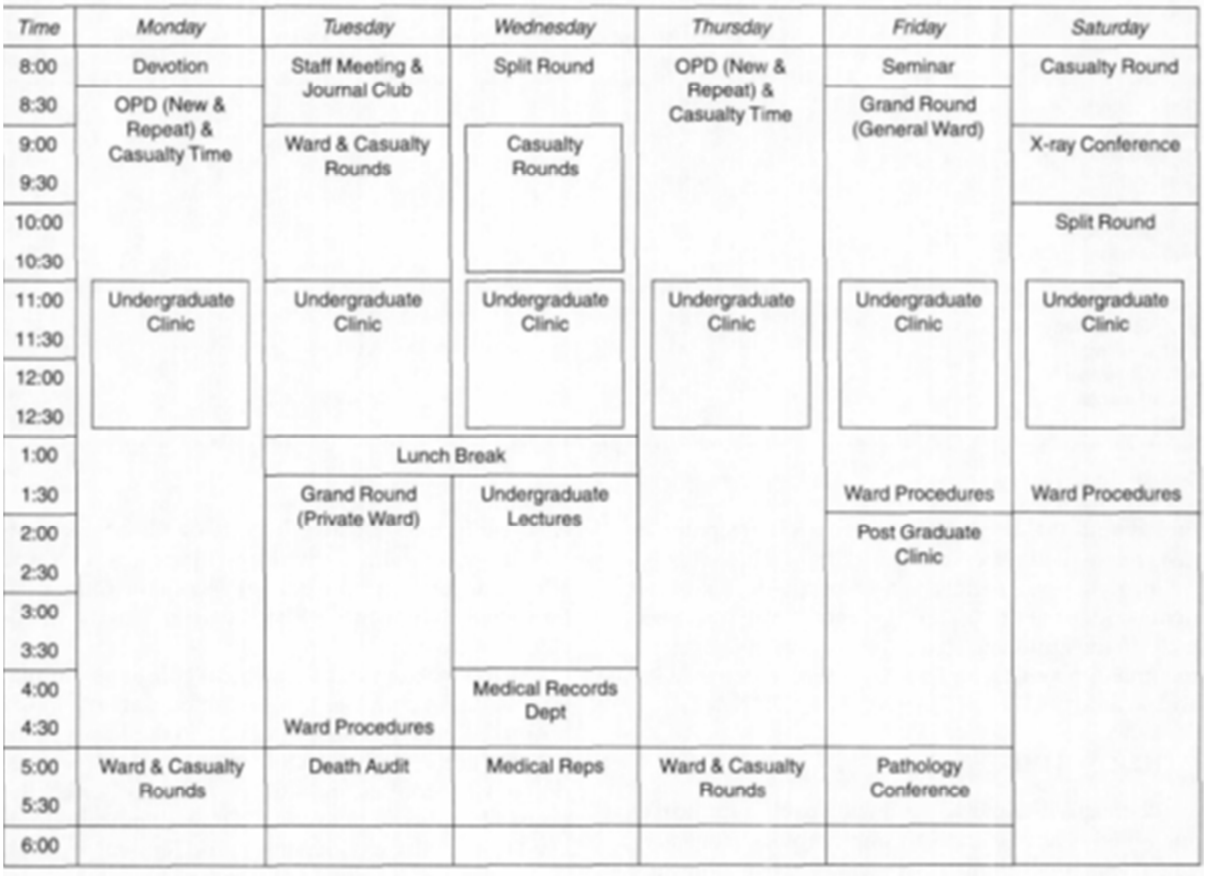
Each unit spends two days a week as full day OPD. Unit I has its OPD days on Monday and Thursday, Unit II on Tuesday and Friday, and Unit III on Wednesday and Saturday. Most of the private patients generally refer to the consultants while most of the general patients are served by the registrars. All patients are seen by First-Come-First-Served Basis.

The current weekly schedule of activities of doctors for a typical unit in the medicine department is given in Figure 1 (adapted from Ramani, 2002).

Table 3: Estimated Weekly Work Load of a Doctor in Department of General Medicine, Source: Hospital Records

Main Activity	**Activities**	**Prof Hrs/week**	**Assc Prof Hrs/week**	**Asst Prof Hrs/week**	….	…..
OPD	Consultation which includes UG teach bedside PG teach bedside	15	15	15		
IPD (Grand Round)	Consultation which includes UG teach bedside PG teach bedside	5	5	5		
IPD (Split Round)	Consultation which includes UG teach bedside PG teach bedside	12	12	12		
Out-Reach		Variable				
Formal Classroom Teaching	UG teaching PG teaching Non Formal (Dist Edu)	4	4	4		
Other academic activities	Journal Club (PG) Seminar (PG) Regulr Staff Meet (PG) Spl Staff Meet (PG) Death Audit	4	4	4		
Quality Circles		1	1	1		
External Exam duties		Variable				
Research		4	4	4		
Admin		4	2	2		
Other Activities						

Note: Activities such as Out-reach services, external exam duties do not happen every week. Work load on such activities are therefore mentioned as ‘Variable’.



Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00	Devotion	Staff Meeting & Journal Club	Split Round	OPD (New & Repeat) & Casualty Time	Seminar	Casualty Round
8:30	OPD (New & Repeat) & Casualty Time				Grand Round (General Ward)	
9:00		Ward & Casualty Rounds	Casualty Rounds			X-ray Conference
9:30						
10:00						Split Round
10:30						
11:00	Undergraduate Clinic	Undergraduate Clinic	Undergraduate Clinic	Undergraduate Clinic	Undergraduate Clinic	Undergraduate Clinic
11:30						
12:00						
12:30						
1:00		Lunch Break				
1:30		Grand Round (Private Ward)	Undergraduate Lectures		Ward Procedures	Ward Procedures
2:00					Post Graduate Clinic	
2:30						
3:00						
3:30						
4:00			Medical Records Dept			
4:30		Ward Procedures				
5:00	Ward & Casualty Rounds	Death Audit	Medical Reps	Ward & Casualty Rounds	Pathology Conference	
5:30						
6:00						

Figure 1: Current weekly schedule of activities of doctors for a typical unit in the medicine department

Outpatient Services: It can be seen from Figure 1 that CMC follows a 3 day cycle for out-patient services. This means that if medicine unit I provides out-patient services on Monday, the same unit will be available for outpatient services only the following Thursday. As a result, repeat visits of the outpatients for doctor's consultation are possible only after a gap of a minimum of two days. The minimum turnaround time for outpatients is three days.

Given that the medicine department serves around 400-450 outpatients daily, doctors in the medicine department usually stretch themselves beyond the normal working hours for OPD consultation.

Inpatient Care: Extended OPD hours mean delayed ward visits on OPD days. For example, assume that medicine unit I provides OPD services on Mondays and Thursdays. Large daily OPD load for the medicine department delays the ward visit of its doctors on Mondays and Thursdays. It is necessary that doctors visit their inpatients at least once every day.

Teaching and Research: The ever increasing load on patient care is causing severe constraints on the doctors' time for teaching and research. Grand round is a unique feature of CMC, Vellore, not practiced by other medical colleges in India. CMC believes that grand rounds significantly increases the value of UG teaching as all the UG students get an opportunity to review all the cases in the medicine department.

Our observations in this section on the current activities of doctors in the medicine department highlight the demand on the doctors' time for various activities. The current schedule of activities also raises serious questions regarding the ability of CMC doctors to carry out patient care, teaching and research activities satisfactorily.

As mentioned earlier, the doctors' load on teaching UG and PG programs has been doubled beginning 2013-14, and the outpatient load continues to increase by 10-15 percent annually. It has therefore become very essential for the CMC management to evolve a plan of activities for its doctors so as to ensure that they are able to carry out all their activities effectively and efficiently without jeopardizing the quality of patient services and teaching activities. Currently, patients have to stay longer, which increases their duration of stay in the hospital and the doctors have to stretch their OPD hours beyond the regular limit, which adversely affects their other activities such as research, teaching etc.

To develop a plan of doctor's activities, we need to quantify the workload of a doctor especially to attend outpatients/day. To achieve this objective, we first classify the different types of outpatients and understand the flow of these patients in the hospital. Then using percentages of different types of patients that visit on a day, we propose alternate timetables for attending to outpatients that can reduce the patient's length of stay at CMC and also improve doctor's productivity. In the next section, we discuss the current process for outpatient visits that are followed at CMC.

4. Outpatient Classification and Flow

All the new outpatients, who have their first visit in CMC, have two options, either they can pay extra to consult their preferred doctor, called *Private Patients* or they will be consulted by any available doctor that is present for OPD on the same day itself, called *General Patients*. Private patients have to pay more amount of money at time of registration only, and they are given an appointment with their preferred consultant. Afterwards, the patients follow the same path during the due course of their treatment. However, if it is not the first visit of any patient, i.e. if it is the repeat visit of any patient, then the patient is always given consultation by the same doctor, and he/she does not have to pay more fees to go to the same doctor.

Every patient goes through the same procedure and the same sequence of events, i.e, Registration, Consultation, Pay for Investigations or medicines, investigations and at last, medication. We describe these processes now (see Figure 2).

4.1 *Registration:*

Registration is the process by which a patient is registered for OPD treatment in CMCH. The registration desk is open daily, from Monday to Saturday, 8 AM to 11 AM. The private patients, here, are allotted the approximate time, date and place of consultation with their preferred doctor, while, the general patients are consulted by any available doctor, on the same day of registration itself. If the patients are repeat patients, then they are assigned to the

same doctor, whom they had consulted during their last visit. Every patient is allotted a unique registration number that remains valid for one year from the date of registration.

4.2 *Consultation:*

The consultation hours at CMCH is from 8 AM to 5 PM daily, however, if number of patients that are registered for the day is large enough to be served in the time limit, then the doctors have to stretch their OPD time to make sure that all patients are served. For new patients, the fresh case sheets are prepared to have a record of their activities in their due period in CMCH. This can either be done by consultant himself or by the undergraduate students or interns under him. Undergraduate teaching is also done in parallel with OPD hours. For repeat patients, it is ensured that the case sheets, tests and investigations results, and all relevant records of previous visits are available at the time of consultation. All of their past records are checked first in their consultation and then the further procedure is followed. All of the patients are advised to do one or more from:

1. Investigations
2. Medication
3. Cross-Referrals
4. Admitted as Inpatient

And if further investigations are not required or, the patient is unsatisfied with the services provided, the patient leaves the OPD system. Figure 2 shows the OPD service process for a patient in CMC Hospital:

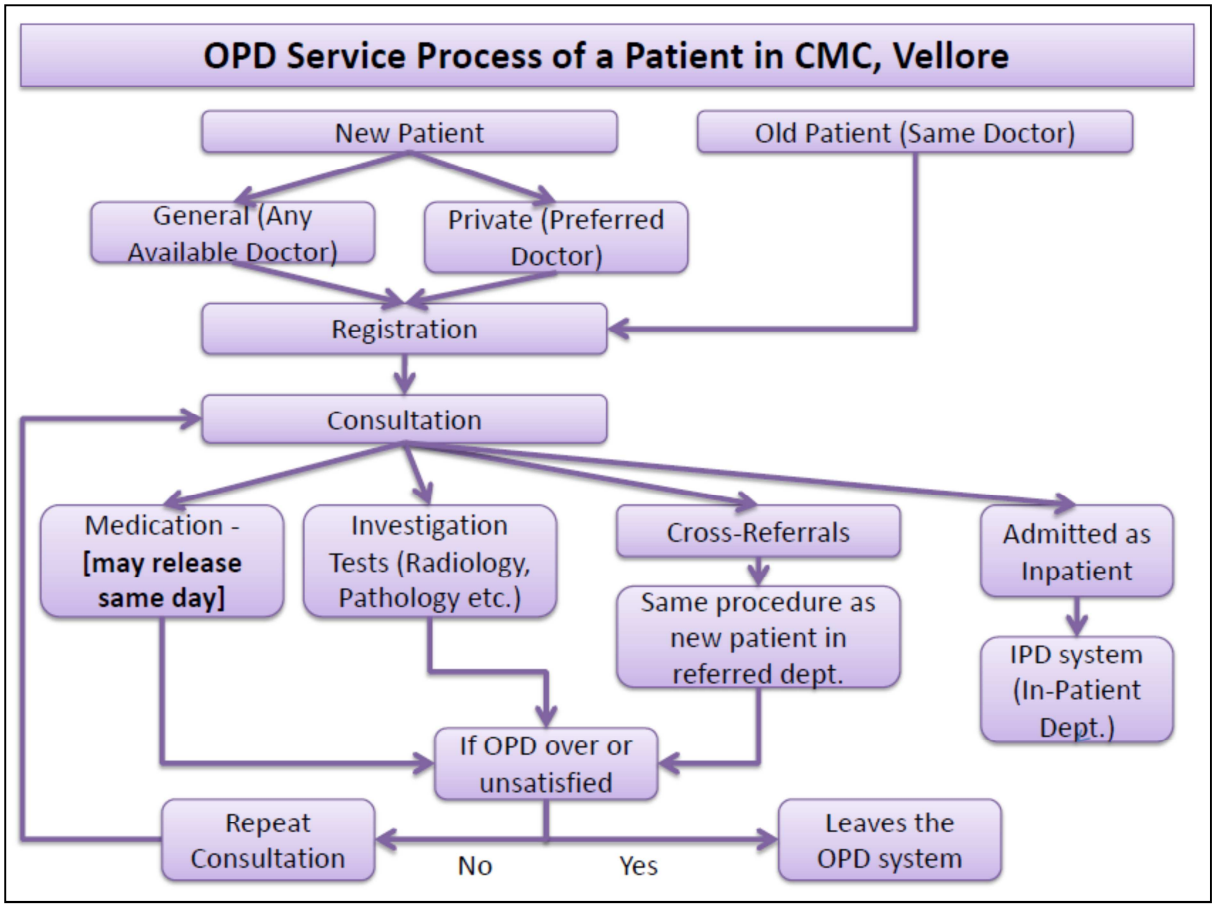


Figure 2: OPD Service Process of a Patient

5. Data and Process Assumptions

The daily load of all the outpatients for a unit in Medicine Department is approximately 400, from which, 130 patients are new and the rest 270 patients are the repeat patients. And, the same ratio is for private patients and general patients also. This is also shown in Table 4.

Table 4: Statistics of Patients types and load per day on a clinical unit

Patient	Private	General	Total
New	40	90	130
Repeat	90	180	270
	130	270	400

From data analysis, it has been found that about 40% of all the outpatients i.e., 50 patients leave the system after their 2nd visit, another 30% i.e. 40 patients leaves after 3rd visit, 15% i.e., 20 patients leaves after 4th visit, and the remainder of the patients leaves after their 5th visit.

The time taken for consultation by any doctor depends on whether the patient is new or repeat and further if the patient is private or general. To estimate the doctor's workload, we consider two options for the approximate time taken by doctors for the different type of patients (See Table 5 and Table 6): Option 1 considers a larger visit time than Option 2 for private patients.

Table 5: Time taken by doctors for consultation, Option 1

Patient	Private (mins.)	General (mins.)
New	15	10
Repeat	8	5

Table 6: Time taken by doctors for consultation, Option 2

Patient	Private (mins.)	General (mins.)
New	20	10
Repeat	10	5

6. Current and Proposed OPD Process Analysis

The current and proposed OPD process analysis is performed to achieve the patient arrival rates on Mondays and Thursdays with two different OPD hour options. We use the following notations to describe the patient arrival and departure process.

- Let A^M and A^T be the number of new outpatients entered this week Monday (M) and Thursday (T) respectively

- Let $_{-1}A^{M}$ and $_{-1}A^{T}$ be the number of new patients that arrived during the Monday and Thursday of the previous week respectively
- Let $_{-2}A^{M}$ and $_{-2}A^{T}$ be the number of new patients that arrived during the Monday and Thursday before two weeks respectively

Figure 3 shows that for both, Monday and Thursday, the total OPD load is 400 patients, 130 new and 270 repeat patients. In the current scenario, there are two full day OPD sessions on Mondays and Thursdays for unit 1. It is desired to get the patient load on each day and the distribution i.e. the statistics of new and repeat patients. Figure 3 describes the patient load on individual days:

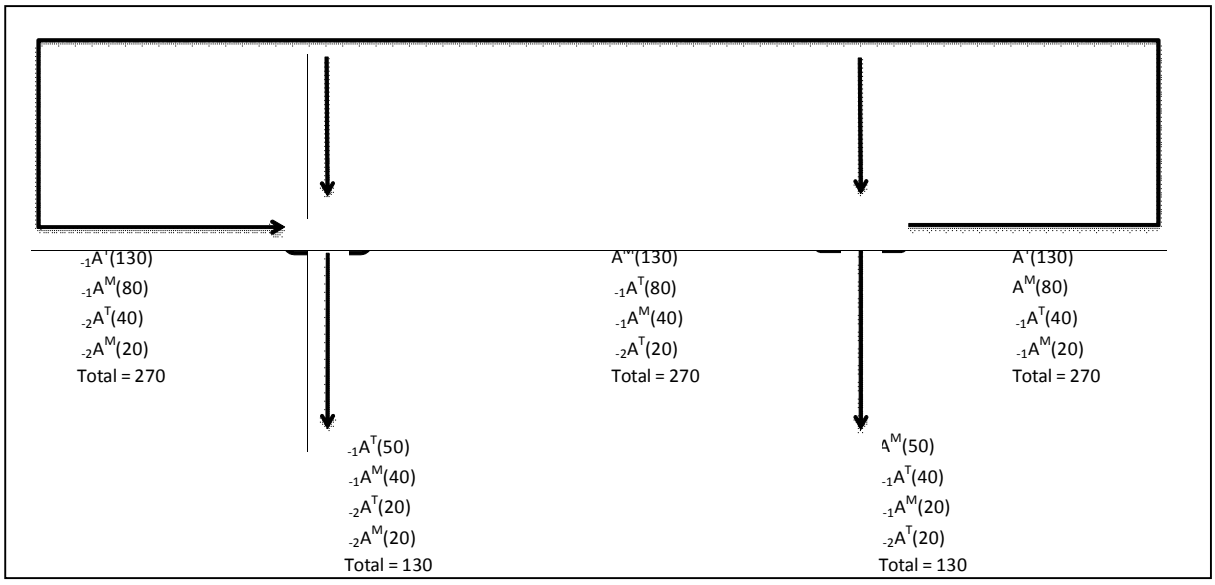


Figure 3: Current OPD load per week for Unit I

The arrival and departure rate analysis for the current OPD process is explained in Appendix A. We can see that based on our assumptions, we have on Monday 130 repeat patients that arrived on the Thursday of the previous week, 80 repeat patients that arrived on the Monday of the previous week, 40 repeat patients that arrived on the Thursday (two weeks ago), and 30 repeat patients that arrived on Monday (two weeks ago). This results in 270 repeat patients and 130 new patients on Mondays. Likewise, we have 270 repeat patients and 130 new patients on Thursdays.

We now analyze the following change in the OPD schedule. For unit I, introducing two OPD sessions for only repeat patients on Wednesday evening and Saturday morning reduces the OPD load on regular days (Monday and Thursday). Figure 4 describes the patients load on the unit, per week. The arrival and departure rate analysis for the proposed OPD process is explained in Appendix B.

The Wednesday and Saturday sessions are only for repeat patients, no new patients are served in these sessions. The figure shows that for Monday and Thursday, the total number of patients served is 230, each day, and for Wednesday and Saturday, the number of patients served is 170, each day.

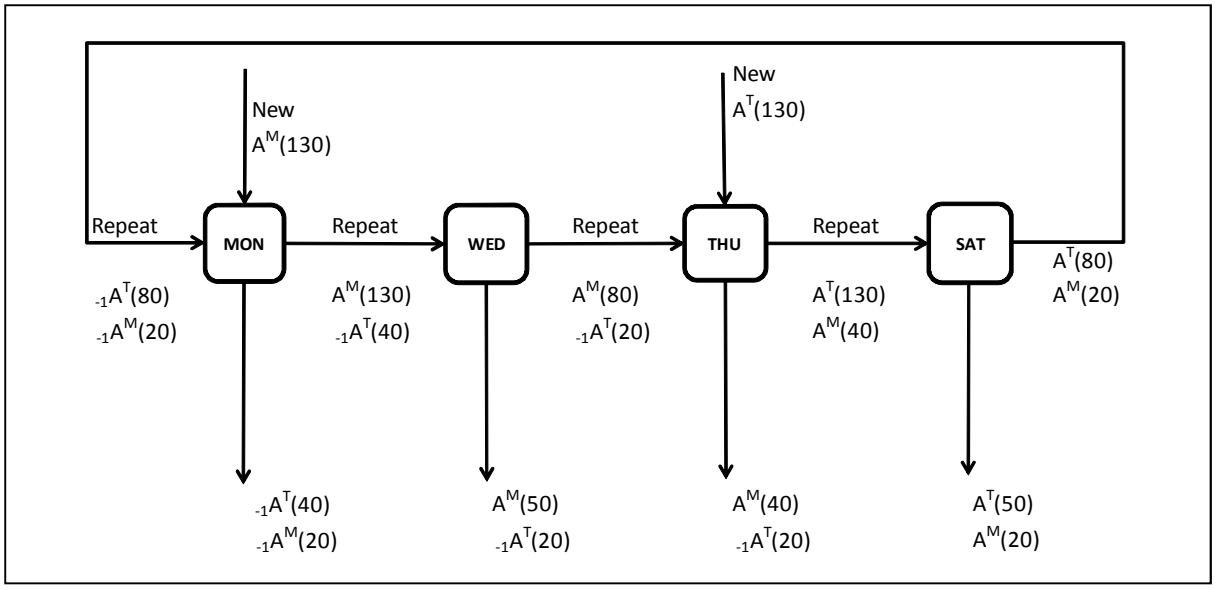


Figure 4: OPD load per week by proposed OPD process for Unit I

7. Sequencing Activities and Developing Timetables

In order to build up the time-table, it is first desired to check which activities amongst all, have greater affinity towards the others. The affinity check among the activities will help in sequencing of the activities in the time-table. An affinity matrix is developed, which is shown in Figure 5.

Activities	Devotion	Grand Rounds	Split Rounds	OPD	UG Classroom	PG clinic	Death Audit	Journal club	Seminars	Clinical meeting	Quality Circles	Research	Adm. Activities
Devotion													
Grand Rounds													
Split Rounds													
OPD		A	A										
UG Classroom													
PG clinic													
Death Audit													
Journal club							A						
Seminars							A	A					
Clinical meeting							A	A	A				
Quality Circles													
Research							A	A	A	A			
Adm. Activities													

Figure 5: Affinity matrix for different activities

As clear from the above matrix, it is clear that Death Audit, Journal Club, Seminar and Clinical Meetings have great affinity towards each other and also with Research sessions, so they can be sequenced next to each other in a time-table.

If the time taken for consultation by doctors is assumed by the Table 5, and the patient load is taken as provided in Table 4, then the total time taken by each doctor (8 doctors are taken per unit), for the total number of 400 patients on each day can be estimated to be approximately 6.5 hours. If the patient load is increased to 500 per day (following the distribution as indicated in Table 7) then the total time taken by each doctor to serve all 500 patients is approximately 8 hours.

Table 7: Statistics for Patient types and patient load per day

	Private	General	Total
New	50	110	160
Repeat	110	230	340
	160	340	500

Both situations (with a patient load of 400 or 500), with the time taken for consultation indicated by Table 5, can be easily managed in a regular 2-day OPD cycle by a unit. The time-table to be followed is described in Figure 6.

Time		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8 - 8:30		Devotion		Journal Club			
8:30 - 9			Clinical Meeting				Research
9 - 9:30				Seminar			
9:30 - 10		OPD			OPD	Grand Round (General)	
10 -10:30			Grand Round (Private)	Split Round			Split Round
10:30 - 11							
11 -11:30							
11:30 - 12		UG Clinic	UG Clinic	UG Clinic	UG Clinic	UG Clinic	UG Clinic
12 - 12:30							
12:30 - 1							
1 - 1:30		LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	
1:30 - 2							
2 - 2:30							
2:30 - 3				Research			
3 - 3:30		OPD	UG Lectures		OPD	PG Clinic	
3:30 - 4							
4 - 4:30				Aminis-			
4:30 - 5				tration			
5 - 5:30		Split	Death		Split	Quality	
5:30 - 6		Round	Audit		Round	Circles	

Figure 6: Time-Table for Unit I with two full OPD days per week (Ramani, 2002)

The time-table above also provides flexibility in activities such as UG Clinic. UG Clinic has to be done in parallel to OPD or Grand or Split Rounds. Since it is for only two hours, the doctors can manage the time of UG Clinic according to their own convenience. The time spent per activity according to the above proposed time table and the required limit is compared in Table 8.

Table 8: Time spent on different activities by doctors per week

Activity	Required (hrs.)	Proposed (hrs.)
Devotion	0.5	0.5
Grand Rounds	5	8
Split Rounds	12	8
OPD	15	15.5
UG Classroom	2	3
PG clinic	2	3
Death Audit	1	1
Journal club	1	1
Seminars	1	1
Clinical meeting	1	2
Joint Seminar	0	0
Quality Circles	1	1
Research	4	4
Adm. Activities	4	2
Total	49.5	50

If the time taken for consultation is assumed by Table 6, and the patient load is 400 per day, then the total time taken to serve all the patients by a doctor is 7.3 hours. This can also be easily managed according to the same time-table shown is Figure 6.

Now, for the same consultation time (Table 6), with a patient load is 500 per day, the time required to serve all the patients by a doctor is about 9.1 hours. This indicates that for the whole week, more than 18 hours would be required for only OPD sessions, and this much amount of time will be difficult to allocate only for OPD sessions per week.

As per the 2 full days OPD time-table, and the patient load up to 500 per day, it results in doctors spending much more time than usual OPD hours on the two OPD days, in order to serve all of the patients that are registered for the day. Suppose for Unit I, the doctors have to devote extra time on Monday and Thursday, another solution could be to divide the patient load per week into two more sessions other than Monday and Thursday to reduce the load per day. The two new sessions could be introduced on Wednesday evening and Saturday

morning. These sessions are only for *repeat* patients. No new patients are served in these sessions.

The time-table proposed with 4 half days OPD to reduce the OPD load per day is described in Figure 7. The time spent per activity according to the above proposed time table and the required limit is compared in Table 8.

Time		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8 - 8:30		Devotion	Clinical Meeting	Journal Club	OPD	Quality Circles	OPD
8:30 - 9		OPD					
9 - 9:30				Seminar		Grand Round (General)	
9:30 - 10							
10 -10:30				Death Audit			UG Clinic
10:30 - 11			Grand Round				
11 -11:30		UG Clinic	UG Clinic	Split Round/ UG Clinic	UG Clinic	UG Clinic	
11:30 - 12							Split Round
12 - 12:30							
12:30 - 1							
1 - 1:30		LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	
1:30 - 2							
2 - 2:30		Research	UG Lectures	OPD	Research	PG Clinic	
2:30 - 3							
3 - 3:30							
3:30 - 4							
4 - 4:30		Split Round			Split Round		
4:30 - 5							
5 - 5:30			Adminis-tration			Adminis-tration	
5:30 - 6							

Figure 7: Proposed Time-Table with 4 half days OPD per week

With the time-table described in Figure 7, the OPD hours per week will be increased to 17.5, and hence, much more patient load can now be handled than the time-table with two full OPD days. Now, using the same analysis as before, for capturing the effect of previous week on current week, to calculate the number of patients to be seen per Monday and Thursday, and Wednesday and Saturday, it turns out that out of 1000 patients per week, 290 patients (both new and repeat) have to be served each Monday and Thursday, and 210 patients (only repeat) have to be served each Wednesday and Saturday sessions. The arrival and departure rate analysis for the proposed OPD process is explained in Appendix C. It is assumed here also, that 40% patients, i.e. 60 patients leaves after their 2nd visit, 30% i.e. 50 after 3rd visit, another 15% i.e. 20 after 4th visit and remaining 15% after their 5th visit. Note than the above values are not the exact percentages which are quoted above, it is the nearest number chosen for the sake of easy calculations.

Table 9: Time spent on different activities by doctors per week

Activity	Required (hrs.)	Proposed (hrs.)
Devotion	0.5	0.5
Grand Rounds	5	6.5
Split Rounds	12	7
OPD	15	17.5
UG Classroom	2	3
PG clinic	2	3
Death Audit	1	1
Journal club	1	1
Seminars	1	1
Clinical meeting	1	2.5
Joint Seminar	0	0
Quality Circles	1	1
Research	4	4
Adm. Activities	4	2
Total	49.5	50

Estimating service times to attend the patients on Monday, Tuesday, Wednesday and Thursday:

The time required for consultation of new and repeat patients is provided and also the number of new patients is known, and assuming that the repeat general patients are twice the number to the repeat private patients, the total time required to serve all the patients on Monday/Thursday turns out to be 6.15 hours.

Similarly, the time required to serve all the patients on Wednesday/Saturday is 2.9 hours. According to the time-table in Figure 7, the time allocated to OPD on Monday and Thursday is approximately 5 hours, and on Wednesday and Saturday, it is 4 hours. So to balance the workload across the OPD days, a fixed number of repeat patients have to be registered on Monday and Thursday sessions, which can be handled in 5 hours. This number turns out to be 205, as per the increased consultation time in Table 3, including all new patients and 45 repeat patients. Now, these 45 patients can either be registered purely on a First-Cum-First-Serve basis, or preferably 30 patients who entered on last week Monday and have their last visit, should be given preference first, and 15 from the last week Thursday on a First-Cum-First-Serve basis. And the remaining 85 repeat patients who have their OPD on Monday, but due to time constraint were not been able to get consultation, should be shifted to Wednesday session, as we have extra time available there than required.

8. Conclusions

In this paper, we provide alternate time-tables for servicing OPD patients that can reduce the minimum outpatient turnaround time from the current 3 days to 2 days.

If the patient load is up to 400 per day and the consultation time is from any of the two options provided in Table 5 or 6, the time-table with two full OPD days per week, as shown in Figure 6 would be the best. Two full days OPD cycle is also preferable if the patient load increases to 500 per day and the time for consultation is assumed by Option 1 (lower private patient appointment times). The problem arises only if the patient load is increased to 500 per day and the consultation time is also increased (Table 6), then the 4-half day OPD schedule would be best as shown in Figure 7.

If the hospital follows 4 half days OPD schedule, then, clearly the patients are able to get over with their OPD treatment in much less time than before, as in one week now, they can receive consultation 4 times rather than two times previously. Even if some of the patients in 4-day half OPD schedule are shifted from Monday/Thursday to Wednesday/Saturday, due to time-constraint, they still are completing their OPD cycle in much less time than the previous 2 full day OPD schedule. Both the 2 full days OPD schedule and 4 half days OPD schedule can be compared on the basis of the time spent per activity (see Table 10). Moreover, both the time-tables above also provides flexibility in activities such as UG Clinic, which can be done in parallel to OPD or Grand or Split Rounds.

The focus of this study is to develop a plan to manage the growth in OPD patient volumes. However, the intake of both UG and PG students is also expected to increase. Due to increase in the student batch size, grand ward visits (bed-side teaching for all students) can be substituted with class-room teaching, where the special cases can be shared with a larger audience. By eliminating the grand rounds, there can also be an increased commitment to journal clubs, PG seminars, and research activities.

Table 10: Comparison of both schedules

Activity	Required (hrs.)	4 half days OPD	2 full days OPD
Devotion	0.5	0.5	0.5
Grand Rounds	5	6.5	8
Split Rounds	12	7	8
OPD	15	17.5	15.5
UG Classroom	2	3	3
PG clinic	2	3	3
Death Audit	1	1	1
Journal club	1	1	1
Seminars	1	1	1
Clinical meeting	1	2.5	2
Quality Circles	1	1	1
Research	4	4	4
Adm. Activities	4	2	2
Total	49.5	50	50

References:

1. Ramani, K.V, "Scheduling Doctors' Activities at a Large Teaching Hospital". "Production and Inventory Management Journal" – First/Second Quarter, 2002
2. Ramani, K.V, CMC Hospital, Vellore (A): Managing OPD services, Case Number: IIMA/CMHS0014(A), 2012
3. Ramani, K.V, CMC Hospital, Vellore (B):Scheduling Doctors' Activities, Case Number: IMA/CMHS0014(B), 2012

Appendix A: Arrival and departure rate analysis for the current system with two full OPD days

According to the data from Table 4: A^M, A^T, $_1A^M$, $_{-1}A^T$, $_{-2}A^T$, and $_{-2}A^M$ are 130 each. As previously stated, approximately 50 patients leave the system after their 2nd visit, another 40 leave after 3rd, 20 after 4th, and remaining 20 patients leave after their 5th visit. Now, to study the effect of previous weeks on current week, day-to-day analysis is performed (see Table A1).

Table 7: Effect of previous week patients on current week

Week	Day	Patients In (for Consultation)	Patients over with OPD (After Consultation)
Week	Monday	$_{-2}A^M$	
(-2)	Thursday	$_{-2}A^T + _{-2}A^M$	$_{-2}A^M(50)$
Week	Monday	$_{-1}A^M + _{-2}A^T + _{-2}A^M(80)$	$_{-2}A^M(40) + _{-2}A^T(50)$
(-1)	Thursday	$_{-1}A^T + _{-1}A^M + _{-2}A^T(80) + _{-2}A^M(40)$	$_{-1}A^M(50) + _{-2}A^M(20) + _{-2}A^T(40)$
Week	Monday	$A^M + _{-1}A^T + _{-1}A^M(80) + _{-2}A^T(40) + _{-2}A^M(20)$	$_{-1}A^T(50) + _{-1}A^M(40) + _{-2}A^M(20) + _{-2}A^T(20)$
(Current)	Thursday	$A^T + A^M + _{-1}A^T(80) + _{-1}A^M(40) + _{-2}A^T(20)$	$A^M(50) + _{-1}A^T(40) + _{-1}A^M(20) + _{-2}A^T(20)$

In the above table, the number shown in the bracket with any day is the number of patients remaining from that day, going for another visit. The above analysis is done to calculate the number of patients having their OPD in current week only. Therefore, those patients who entered in the previous weeks and have their OPD falling in the current week are only considered.

Also, it is clear from the above table, that for current week Monday and Thursday, total 400 patients walk in for consultation, out of which 130 are new and 270 repeat patients.

For current week Monday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate =

$\{A^M(130)\} + \{_{-1}A^T(130) + _{-1}A^M(80) + _{-2}A^T(40) + _{-2}A^M(20)\} = \{130\} + \{270\} = 400/day$

Effective Departure rate = {patients going to Thursday for next visit} + {patients leaving the OPD}

Effective Departure rate =

$\{A^M(130) + _{-1}A^T(80) + _{-1}A^M(40) + _{-2}A^T(20)\} + \{_{-1}A^T(50) + _{-1}A^M(40) + _{-2}A^M(20) + _{-2}A^T(20)\} = \{270\} + \{130\} = 400/day$

Now, for current week Thursday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate =

$\{A^T(130)\} + \{A^M + {}_{-1}A^T(80) + {}_{-1}A^M(40) + {}_{-2}A^T(20)\} = \{130\} + \{270\} = 400/day$

Effective Departure rate = {patients going to next Monday for next visit} + {patients leaving the OPD}

Effective Departure rate =

$\{A^T(130) + A^M(80) + {}_{-1}A^T(40) + {}_{-1}A^M(20)\} + \{A^M(50) + {}_{-1}A^T(40) + {}_{-1}A^M(20) + {}_{-2}A^T(20)\} = \{270\} + \{130\} = 400/day$

Therefore, for each day, it is clear the effective arrival rate is equal to the effective departure rate.

Appendix B: Arrival and departure rate analysis for the proposed system with four half OPD days

In order to check the effect of previous week on current week, same analysis is performed, using the same terminology as for the current OPD analysis. Again, the analysis is done to calculate the number of patients having their OPD in current week only. Therefore, those patients from previous weeks who have their OPD falling in the current week are only considered. This is described in Table B1.

Table B1: Effect of previous week patients on current week

Week	Day	Patients In (for Consultation)	Patients over with OPD (After Consultation)
	Monday	$_{-1}A^{M}$	
Week	Wednesday	$_{-1}A^{M}$	$_{-1}A^{M}(50)$
(-1)	Thursday	$_{-1}A^{T} + _{-1}A^{M}(80)$	$_{-1}A^{M}(40)$
	Saturday	$_{-1}A^{T} + _{-1}A^{M}(40)$	$_{-1}A^{T}(50) + _{-1}A^{M}(20)$
	Monday	$A^{M} + _{-1}A^{T}(80) + _{-1}A^{M}(20)$	$_{-1}A^{T}(40) + _{-1}A^{M}(20)$
Week	Wednesday	$A^{M} + _{-1}A^{T}(40)$	$A^{M}(50) + _{-1}A^{T}(20)$
(Current)	Thursday	$A^{T} + A^{M}(80) + _{-1}A^{T}(20)$	$A^{M}(40) + _{-1}A^{T}(20)$
	Saturday	$A^{T} + A^{M}(40)$	$A^{T}(50) + A^{M}(20)$

Following this schedule, will reduce the load on regular days of Monday and Thursday, and hence saving doctors much time on these days. Although, the total OPD load for a week is still the same, as in the current method, 400 patients are served on both Monday and Thursday, giving a total of 800 patients per week, and in the proposed method also, 230 patients on Monday and Thursday, and 170 patients on Wednesday and Saturday, again giving a total load of 800 patients per week.

For current week Monday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = $\{A^{M}\} + \{_{-1}A^{T}(80) + _{-1}A^{M}(20)\} = \{130\} + \{100\} = 230/day$

Effective Departure rate = {patients going to Wednesday for next visit} + {patients leaving the OPD}

Effective Departure rate = $\{A^{M}(130) + _{-1}A^{T}(40)\} + \{_{-1}A^{T}(40) + _{-1}A^{M}(20)\} = \{170\} + \{60\} = 230/day$

For current week Wednesday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = $\{0\} + \{A^{M}(130) + _{-1}A^{T}(40)\} = \{0\} + \{170\} = 170/day$

Effective Departure rate = {patients going to Thursday for next visit} + {patients leaving the OPD}

Effective Departure rate = $\{A^{M}(80) + _{-1}A^{T}(20)\} + \{A^{M}(50) + _{-1}A^{T}(20)\} = \{100\} + \{70\} = 170/day$

For current week Thursday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = {A^T (130)} + {A^M (80) + $_{-1}A^T$ (20)} = {130} + {100} = 230/day

Effective Departure rate = {patients going to Saturday for next visit} + {patients leaving the OPD}

Effective Departure rate = {A^T (130) + A^M (40)} + {A^M (40) + $_{-1}A^T$ (20)} = {170} + {60} = 230/day

For current week Saturday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = {0} + {A^T (130) + A^M (40)} = {0} + {170} = 170/day

Effective Departure rate = {patients going to next Monday for next visit} + {patients leaving the OPD}

Effective Departure rate = {A^T (80) + A^M (20)} + {A^T (50) + A^M (20)} = {100} + {70} = 170/day

Appendix C: Arrival and Departure rate analysis with 500 patients per day and four half days OPD schedule

The analysis is described in Table C1.

Table C1: Effect of previous week patients on current week

Week	Day	Patients In (for Consultation)	Patients over with OPD (After Consultation)
	Monday	$_{-1}A^{M}$	
Week	Wednesday	$_{-1}A^{M}$	$_{-1}A^{M}(60)$
(-1)	Thursday	$_{-1}A^{T} + _{-1}A^{M}(100)$	$_{-1}A^{M}(50)$
	Saturday	$_{-1}A^{T} + _{-1}A^{M}(50)$	$_{-1}A^{T}(60) + _{-1}A^{M}(20)$
	Monday	$A^{M} + _{-1}A^{T}(100) + _{-1}A^{M}(30)$	$_{-1}A^{T}(50) + _{-1}A^{M}(30)$
Week	Wednesday	$A^{M} + _{-1}A^{T}(50)$	$A^{M}(60) + _{-1}A^{T}(20)$
(Current)	Thursday	$A^{T} + A^{M}(100) + _{-1}A^{T}(30)$	$A^{M}(50) + _{-1}A^{T}(30)$
	Saturday	$A^{T} + A^{M}(50)$	$A^{T}(60) + A^{M}(20)$

According to the data from Table 7: A^{M}, A^{T}, $_{-1}A^{M}$, $_{-1}A^{T}$ = 160

For current week Monday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = $\{A^{M}\} + \{_{-1}A^{T}(100) + _{-1}A^{M}(30)\} = \{160\} + \{130\} = 290$/day

Effective Departure rate = {patients going to Wednesday for next visit} + {patients leaving the OPD}

Effective Departure rate = $\{A^{M}(160) + _{-1}A^{T}(50)\} + \{_{-1}A^{T}(50) + _{-1}A^{M}(30)\} = \{210\} + \{80\} = 290$/day

For current week Wednesday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = $\{0\} + \{A^{M}(160) + _{-1}A^{T}(50)\} = \{0\} + \{210\} = 210$/day

Effective Departure rate = {patients going to Thursday for next visit} + {patients leaving the OPD}

Effective Departure rate = $\{A^{M}(100) + _{-1}A^{T}(30)\} + \{A^{M}(50) + _{-1}A^{T}(30)\} = \{130\} + \{80\} = 210$/day

For current week Thursday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = $\{A^{T}(160)\} + \{A^{M}(100) + _{-1}A^{T}(30)\} = \{160\} + \{130\} = 290$/day

Effective Departure rate = {patients going to Saturday for next visit} + {patients leaving the OPD}

Effective Departure rate = {A^T (160) + A^M (50)} + {A^M (50) + $_{-1}A^T$ (30)} = {210} + {80} = 290/day

For current week Saturday,

Effective Arrival rate = {New patients} + {Repeat Patients}

Effective arrival rate = {0} + {A^T (160) + A^M (50)} = {0} + {210} = 210/day

Effective Departure rate = {patients going to next Monday for next visit} + {patients leaving the OPD}

Effective Departure rate = {A^T (100) + A^M (30)} + {A^T (50) + A^M (30)} = {130} + {80} = 210/day