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Applying JIT Principles to Resident Education to Reduce Patient Delays: A Pilot Study in an Academic Medical Center Pain Clinic

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Abstract

Objectives. **This study investigated the effect on patient waiting times, patient/doctor contact times, flow times, and session completion times of having medical trainees and attending physicians review cases before the clinic session. The major hypothesis was that review of cases prior to clinic hours would reduce waiting times, flow times, and use of overtime, without reducing patient/doctor contact time.**

Design. **Prospective quality improvement.**

Setting. **Specialty pain clinic within Johns Hopkins Outpatient Center, Baltimore, MD, United States.**

Participants. **Two attending physicians participated in the intervention. Processing times for 504 patient visits are involved over a total of 4 months.**

Intervention. **Trainees were assigned to cases the day before the patient visit. Trainees reviewed each case and discussed it with attending physicians before each clinic session.**

Primary and Secondary Outcome Measures. **Primary measures were activity times before and after the intervention. These were compared and also used as inputs to a discrete event simulation to eliminate differences in the arrival process as a confounding factor.**

Results. **The average time that attending physicians spent teaching trainees while the patient waited was reduced, but patient/doctor contact time was not significantly affected. These changes reduced patient waiting times, flow times, and clinic session times.**

Conclusions. **Moving some educational activities ahead of clinic time improves patient flows through the clinic and decreases congestion without reducing the times that trainees or patients interact with physicians.**

Key Words. **Ambulatory Care; Resident/Fellow Education; Quality Improvement**

Introduction

As part of its mission to train graduates, an academic medical center (AMC) arranges for medical trainees (students, residents, or fellows) to work in ambulatory clinics under the supervision of more experienced attending physicians. In one frequently seen arrangement, the patient–physician interaction occurs in three distinct stages: an initial exam by the trainee, a one-on-one discussion between the trainee and the attending while the patient waits in the examination room, and a joint visit with the patient by the attending/trainee dyad [1]. From an operational perspective, this multistage delivery approach increases process complexity, adding both processing and waiting time in treating patients [2–6].

At our AMC, outpatient pain clinic patient delays, especially later in the clinic session, can become so long that the last patient frequently leaves after the scheduled closing time. This not only adversely affects the patient experience but also incurs operating costs because staff members accrue overtime. To alleviate such delays, a study was conducted to identify root causes for delays and counter-measures to remove them. Consistent with the principles behind just in time (JIT) [7,8], a process map was developed and resource utilization was determined. Not surprisingly, the attending physician was identified as the bottleneck resource. As JIT principles suggest that processing be moved away from the bottleneck resource, we sought ways to reduce the attending physician's workload during the session. The stage in which the discussion between the trainee and attending physician occurs was targeted as the first candidate for reducing work. This stage is the natural candidate as the patient waits in the examination room while this discussion takes place, and when it is shortened it directly reduces the duration of the patient visit. Because we did not want to diminish the critical teaching experience, a pilot intervention of "preprocessing" was proposed whereby much of the discussion between the trainee and attending took place before, rather than during, the clinic session. We hypothesize that this change would reduce processing time while the patient is in clinic and improve process flow without significantly increasing workload for the attending or the trainee during and prior to the session. We also hypothesize that concomitant with this reduction, patient delays and overtime would also fall.

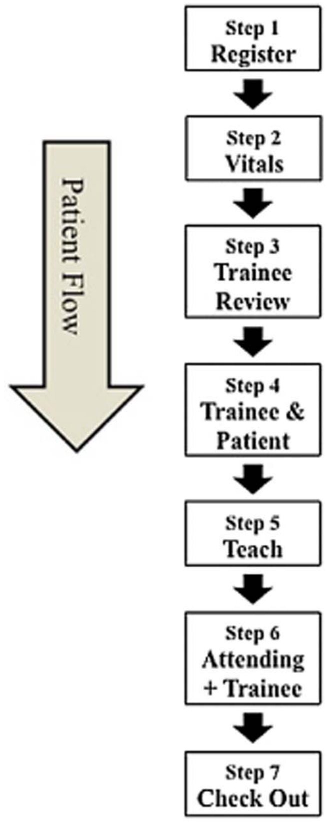

Figure 1 Process flows of the pain clinic: trainee review, trainee's review time before seeing the patient, trainee/patient, and trainee's time with the patient.
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Methods

Patient Process Flow

A graphical depiction of the patient process flow is shown in Figure 1. This system accommodates three distinct types of cases. Roughly 30% of patients are *new*, meaning that this is their first visit to the clinic for this particular condition. Roughly 40% are *returns*, meaning a later visit that still requires time with the attending physician. The remaining visits are routinely handled by the physician's assistant. It is important to account for these patients when considering flow times because the attending physician has to intervene in roughly half of these cases, increasing resource utilization and congestion in the system. The first patient in the morning session is scheduled for 8:00 AM. Each patient registers upon entering the clinic (step 1). A clinical assistant retrieves the patient after an examination room becomes available. Once the patient is in the examination room, the clinical assistant records the patient's vital signs (step 2). For new and return patients, the trainee is then notified of the patient's presence. The trainee reviews the patient's file before entering the room (step 3). The trainee then sees the patient (step 4). Next, the trainee consults with the attending physician (step 5). The attending physician and the trainee then enter the examination room together and interact with the patient (step 6). After completing the visit with the attending physician, the patient proceeds to check out (step 7). Finally, the patient exits the system. Key resources used in these processes include the clinical assistant (in step 2), the trainee (in steps 3, 4, 5, and 6), the attending physician (in steps 5 and 6), the examination rooms (in steps 2, 3, 4, 5, and 6), and clerical staff (in steps 1 and 7).

Intervention

The intervention consisted of the attending physician assigning cases to the trainee the day before the patient visit. The attending then discussed the case with the trainee before patient arrival. In most cases, this discussion took place on the evening before the patient visit. However, if this could not be scheduled, it took place in the morning before the clinic opened. This discussion covered elements included on the checklist shown in Table 1. Each trainee was assigned one to three cases, depending on the next day's schedule, and the preprocessing discussion took between 3 and 5 minutes per case. Care was taken to ensure that return patients would interact with the same trainee who was involved with the initial visit.

Data Collection

Paid observers collected baseline activity time data on 278 new and return patient visits that occurred over a 2-month period. Two attending physicians agreed to pilot the implementation of the preprocessing protocol. Activity time and wait time data for these physicians before the intervention comprised 75 records, a subset of the total patient visits measured. After these two attending physicians implemented preprocessing, paid observers recorded activity times for 226 additional patient visits with these attending physicians. Summary statistics of observed activity times before and after the intervention are presented in Tables 2 and 3.

Table 1 Checklist used by attending physician to outline preprocessing discussion with trainee

Preprocessing Checklist

1. Demographics
2. Is patient a new/return patient?
3. Diagnosis
4. Expected clinical findings
   Symptoms: new patients—review expected symptoms with trainees
   Signs: new patients—review expected signs with trainees
5. Treatment to date: i) interventional; ii) pharmacological; iii) non-interventional (physical therapy, behavioral medicine)
6. Response to treatment
7. Plan
   New patient: i) interventional treatment; ii) pharmacological treatment; iii) non-interventional treatment
   Return patient:
   If patient has improved: continue plan
   If patient has experienced no change in pain or if patient's pain is worse: review treatment
   i) Interventional therapy: consider next step
   ii) Pharmacological therapy: consider increasing dose of medications or adding additional class of medication
   iii) Non-interventional therapy: consider adding next level of multimodal/multidisciplinary treatment

Table 2 Distribution parameters for activity times prior to intervention

Activity	Minimum (min)	Maximum (min)	Mean (min)	SD
Trainee review new	0	50	10.4	9.4
Trainee time new	4	52	20.2	10.8
Teach time new	1	34	12.9	9.2
Att time new	1	37	13.7	8.3
Trainee review return	1	55	10.0	11.4
Trainee time return	2	62	13.4	8.8
Teach time return	1	28	8.8	6.4
Att time return	2	57	9.5	9.9

Trainee review new (return) = trainee's review time before seeing new (return) patient; trainee time new (return) = time trainee spends with new (return) patient; teach time new (return) = time attending spends teaching trainee concerning new (return) patients; att time new (return) = time attending spends with new (return) patient.
SD = standard deviation.

Discrete Event Simulation

The activity time distributions were used as inputs to a discrete event simulation of the clinic that had been

Table 3 Distribution parameters for activity times after intervention

Activity	Minimum (min)	Maximum (min)	Mean (min)	SD
Trainee review new	1	29	6.9	6.1
Trainee time new	2	34	21.4	7.5
Teach time new	1	26	9.1	6.3
Att time new	1	34	13.8	6.8
Trainee review return	1	30	7.5	7.1
Trainee time return	1	25	12.7	5.4
Teach time return	1	16	5.9	4.7
Att time return	1	26	7.5	5.3

Trainee review new (return) = trainee's review time before seeing new (return) patient; trainee time new (return) = time trainee spends with new (return) patient; teach time new (return) = time attending spends teaching trainee concerning new (return) patients; att time new (return) = time attending spends with new (return) patient; types 1 and 2 refer to patient types.
SD = standard deviation.

Table 4 Results of t-tests on the change in teaching times assuming unequal variances

	Average	SD	N	t-Stat	P value
Teach time new Pts w/o preprocessing	12.9	9.2	29		
Teach time new Pts with preprocessing	9.0	6.1	43		
Difference	3.9			2.0	0.02
Teach time ret Pts w/o preprocessing	8.8	6.4	32		
Teach time ret Pts with preprocessing	5.9	4.4	127		
Difference	2.9			2.4	0.01

N = number of observations; Pts = patients; ret = return; SD = standard deviation; t-stat = t-statistic.

created and validated for this clinic in prior work [6]. This approach has been used frequently for similar settings. Introductions to the technique can be found in several studies [9–13]. This approach is required to eliminate several confounding factors outside of study control as explanatory variables such as differences in no-show rates, case volume, and case mix.

Results

We first analyze the observations of activity times, summarized in Tables 2 and 3. For clarity, we will refer to the average duration of step 5 in the patient care process as "teach time." Before the implementation of preprocessing, teach time was 12.9 minutes (standard deviation = 9.2 minutes) for new patients and 8.8 (6.4) minutes for return patients. After implementation of preprocessing, the teach time for new patients fell to 9.0 minutes, and the teach time for return patients fell to 5.9 minutes. Treating activity times as independent variables leads to a straightforward statistical test of significance. Because we are interested in demonstrating that teach times fall, we appropriately used the more conservative one-sided t-test for a reduction in the mean for two variables with different variances. The results outlined in Table 4 show that both changes were statistically significant at $P = 0.02$ and $P = 0.01$, respectively.

The patient's time with a trainee and/or attending physician was similarly compared. Before implementation of preprocessing, average, combined time that patients spent with the physician and trainee was 33.9 (13.6) minutes for new patients and 22.9 (13.2) minutes for return patients. After implementation, those values changed to 35.2 (10.1) minutes for new patients and 20.2 (7.6) minutes for return patients. Thus, our results show that the time patients spent interacting with physicians was not significantly reduced.

Flow metrics derived directly from our observations are presented in Tables 5 and 6. Table 5 presents performance measures related to patient time in the examination room and Table 6 tracks statistics relevant to session completion time. Tables 5 and 6 allow us to compare pre-and post-intervention values of several performance metrics. Table 5 focuses on patient-related flow metrics. The table suggests that improved flow is present. Average values and standard deviation of total wait time and total

Table 5 Averages and (standard deviations) for times in minutes involving patient in examination room

Metric	New Patient Pre-Intervention (N = 92)	New Patient Post-Intervention (N = 48)	Return Patient Pre-Intervention (N = 186)	Return Patient Post-Intervention (N = 178)
Wait for trainee	10.4 (9.4)	6.9 (6.1)	10.0 (11.4)	7.5 (7.1)
Time with trainee	20.2 (10.8)	21.4 (7.5)	13.4 (8.8)	12.7 (5.4)
Trainee wait for AP	20.5 (13.6)	14.8 (9.6)	11.0 (6.7)	11.8 (8.6)
Teach time	12.9 (9.2)	9.1 (6.3)	8.8 (6.4)	5.9 (4.7)
Pt time with trainee/AP	13.7 (8.3)	13.8 (6.8)	9.5 (9.9)	7.5 (5.3)
Total Pt time with MD	33.9 (13.6)	35.2 (10.0)	22.9 (13.2)	20.2 (7.6)
Total wait time	43.8 (18.9)	30.8 (13.0)	29.8 (14.7)	25.2 (12.1)
Total flow time	77.7 (23.2)	66.0 (16.4)	52.7 (19.8)	45.4 (14.3)

Wait for trainee = time patient waits in examination room before first contact with trainee; time with trainee = time patient is alone in examination room with trainee; trainee wait for AP = time trainee waits outside examination room for attending; teach time = time trainee speaks with attending while patient waits in examination room; Pt time with trainee/AP = time patient spends in examination with trainee and attending working together; total Pt time with MD = total time patient spends with trainee and/or attending; total wait time = time patient spends in examination room waiting for a physician; total flow time = sum of total Pt time with MD and total wait time.

Table 6 Session length and overtime

Metric	Pre-Intervention (N = 34)	Post-Intervention (N = 24)
Average makespan	242.0	234.9
STDEV of makespan	21.4	17.9
Sessions with overtime	19	10
Proportion of sessions with overtime	55.9%	44.7%
Average overtime	21.4	14.8
STDEV of overtime	30.7	9.7

Average makespan = average length of session from 8:00 AM until last patient leaves in minutes; sessions with overtime = number of sessions with makespan greater than 240 minutes; proportion of sessions with overtime = number of sessions with overtime divided by total number of sessions; average overtime = average of completion time minus 240 for sessions with overtime.
STDEV = standard deviation.

Table 7 Performance metrics from simulation using standard schedule

Scenario	Flow Time (min)	Wait Time (min)	Session Time (min)
Pre-intervention			
Average	73.6	36.1	275.6
Standard deviation	18.2	16.5	33.5
Post-intervention			
Average	60.2	21.4	247.5
Standard deviation	10.6	8.9	17.5

Flow time = average time between start of check-in and end of checkout for each patient; wait time = average waiting time measured in minutes for all patients in a session; session time = average time between session start and exit of the last patient on the schedule.

flow time are reduced for both new and return patients. Table 6 suggests that average session length was reduced as was the use of overtime. The proportion of sessions using overtime drops and when overtime is used its average value is lower.

However, a direct test of significance cannot be used here. One reason is that the number and mix of patients in the sessions differ from the standard template as part of the day-to-day natural variation of patient volume. In particular, the pre-intervention data reflect sessions that averaged 8.2 new and return patients per session. The post-intervention data reflect sessions that averaged 9.4 visits per session. Even if it had been the case that the number and mix had been invariant, successive patient delays are serially correlated because each session time is an instance of a dynamical system with limited resources. The dynamic interdependence can be explained intuitively by recognizing that if a patient early in the clinic session is delayed, then delays are more apt to also occur for subsequent patients; conversely, if a patient is seen on time, it is more likely that the next patient will also be seen on time. Therefore an alternative method has to be used to isolate the effect of the intervention on delay-related measures.

To isolate the impact of the intervention, we used a discrete event simulation model of this clinic that was used in prior work [6]. We controlled the volume and mix of patients to mimic the setting of our clinic and generated observations from 10,000 replications of a clinic session as presented in Table 7. Given the very large number of simulated sessions, it is sufficient to directly compare the means from sessions using activity time distributions computed pre- and post-intervention. These comparisons, consistent with Table 6, show that as a result of the implementation of preprocessing, average wait time would decrease by 36.1 – 21.4 = 14.7 minutes per patient, a reduction that would apply to all patients. Moreover, flow time would decrease by 73.6 – 60.2 = 13.4 minutes per patient and session time would shorten by 275.6 – 247.5 = 28.1 minutes. Each of these results is significant at $P < 0.01$.

Thus, our results show that moving work outside of clinic hours could improve system performance without a significant decrease in time spent with patients. Thus, the investment of 25 to 42 minutes spent by the attending on preprocessing could result in roughly 175-minute reduction in total patient waiting time and 28.28-minute reduction in overtime operations. On the other hand, as each trainee spent less than 15 minutes on preprocessing, and session time was cut by 28.28 minutes, trainee workload was reduced by roughly 13.28 minutes.

Discussion

The primary goal of this effort was to demonstrate that a viable process change can be implemented to alleviate congestion and delays in an ambulatory clinic setting of the AMC. Applying JIT techniques, one aspect of the way medical training is managed was identified for modification. The change was implemented as a pilot study. Before the change, patients were assigned to trainees in an ad hoc fashion after they arrived at the clinic that resulted in trainees entering into patient interactions having had no preparation. Previous research has shown that this arrangement is common in AMCs [1]. After the change, patient cases were assigned to trainees in advance and discussion ensued between trainee and attending before patient arrival. This interaction routinely took place the night before the appointment or in the morning before the clinic opened. Thus, all cases were preprocessed before the start of the clinic session. We hypothesized that preprocessing would reduce the total workload, delays, patient flow times, and incurred overtime. This was confirmed by direct observation supplemented by a discrete event simulation study. The improvement in patient flows did not lead to significant reduction in the time patients spent interacting with physicians. This allayed the concern of clinic management that such a reduction may have been an unintended consequence of our intervention. Such an effect could have been deemed adverse because research has shown that increasing patient time with physicians increases physician satisfaction [14,15], increases patient satisfaction [16,17], and reduces malpractice suits [18,19].

We note that the use of preprocessing is common in many areas of trainee education. For example, in surgery, the attending and trainee will typically discuss the case in advance of the procedure [20]. However, it appears to be much less common in the settings of ambulatory clinics. Additional work is needed to formally measure other unanticipated effects of our intervention. For example, an informal survey of the trainees involved indicated that they felt more confident when interacting with the patients as a result of the preprocessing conversation. They also stated that their learning was enhanced by the approach. Surprisingly, the attending physicians also noted that they felt more confident when dealing with the patients and that the reduction of congestion in the system made the day seem to flow more smoothly. Both the attending physicians and trainees involved felt that the care delivered to the patients was somewhat improved by the intervention. This anecdotal evidence suggests that further research is needed in the area of educational quality in light of the intervention for improved clinic patient flow. It also appears that a larger scale project of greater duration that includes metrics of trainee, attending, and patient satisfaction will prove to be useful. Such a study of the JIT educational process, conducted in a controlled fashion, is also needed to guarantee that improvement was not a result of the attending and trainees' awareness that they were being studied. In summary, our results indicate that preprocessing holds promise as a means to increase system capacity without increasing waiting time or cost, and without reducing the duration of interactions between trainees and patients.

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