International Journal of Medical Informatics 109 (2018) 49–54

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Research paper

Schedule-based metrics for the evaluation of clinic performance and potential recovery of cancelled appointments

Ken Monahan[a,*], Daniel Fabbri[b]

[a] Division of Cardiovascular Medicine, Vanderbilt Medical Center - Nashville TN, United States
[b] Department of Biomedical Informatics; Vanderbilt Medical Center – Nashville TN, United States

ARTICLE INFO

Keywords:
Appointment scheduling
Appointment template

ABSTRACT

Background: Assessment of outpatient clinic performance is important to optimize patient access. Metrics based on schedule data may assist with assessment of operational efficiency and recovering cancelled appointments.
Objectives: To define schedule-based characteristics of clinic operations and to evaluate potential for recovery of cancelled appointments.
Methods: Sixty-seven weekly cardiology clinics from a single provider over 18 months at an academic medical center were analyzed. Parameters included clinic slots eligible to have patients scheduled (available), slots occupied by appointments (scheduled), and slots for which patients attended the associated visit (appeared). Rates of usage (scheduled/available), appearance (appeared/scheduled), and utilization (appeared/available = usage rate*appearance rate) were calculated. Surplus slots were defined as the difference between available slots and slots occupied by patients that appeared. Cancellation lag-time was defined as the interval between a cancellation and the appointment time. If a patient did not notify the clinic regarding a non-appearance, cancellation lag-time was set to zero. To quantify the impact of a change in clinic operations on efficiency, these metrics were used to evaluate a different cardiologist's clinic before and after its physical location moved.
Results: For approximately 900 patient visits, usage and appearance rates were ~ 80%, yielding a utilization rate of ~2/3. On average, there were nearly 8 surplus slots per clinic. Approximately 30% of cancellation lag-times had positive values and nearly half of positive cancellation lag-times were > 3 h, indicating potential for recovery of those appointments. The intervention analysis showed that usage rate decreased and surplus slots per clinic increased significantly after a change in clinic location.
Conclusions: Schedule-based analysis provides a framework to assess changes to clinic operations, identify mechanisms underlying inefficiency, and suggest solutions for improving clinic performance (i.e. more schedulers in response to low usage rates). Cancellation lag-time analysis suggests recovering a portion of same-day cancellations is plausible.

1. Background/Significance

Objective evaluation of outpatient clinic performance is important to optimize patient access while simultaneously maximizing revenue. While many attributes of clinic performance are intangible, there are at least 3 components that are potentially measureable: availability of appointment slots, scheduling of patients into those slots, and whether patients appear for scheduled appointments.

Both remote and more contemporary efforts [1–7] have focused on forecasting the likelihood of individual patients appearing for appointments by incorporating numerous co-variates into multivariate regression models. Using this technique, at least one commercial application claims to have improved scheduling efficiency and provider income [8]. Prior work has also explored accommodating same-day appointment requests via incorporation of scheduling 'rules', such as assigning appointment duration based on assignment of the visit into a pre-defined category (acute problem, follow-up of known problem, etc…)[9–11]. However, these studies relied on computer simulations to evaluate clinic performance and the available estimates of appearance rates and appointment categories may not be generally applicable or practical. For example, an appearance rate of 98–99% was used in an analysis of Canadian primary care clinics [9] and schedulers needed to choose from 8 visit types in a study of a Women's Health Clinic [12].

As a complement to the predictive and simulation approaches, development and integration of availability, scheduling, and appearance metrics may provide a more complete, widely applicable, and readily adaptable characterization of clinic performance. Rather than focusing on individual patient behavior or constructing models and simulations

* Corresponding author at: Division of Cardiovascular Medicine; Vanderbilt Medical Center 1215 21st Avenue – Medical Center East 5th floor, Nashville, TN, United States.
E-mail address: ken.monahan@vanderbilt.edu (K. Monahan).

https://doi.org/10.1016/j.ijmedinf.2017.11.001
Received 14 September 2017; Received in revised form 31 October 2017; Accepted 3 November 2017

of a specific clinic's operations, this methodology involves analysis of features common to all outpatient clinics. These attributes originate from, and are intrinsic to, the clinic schedule itself, defined as the collection of appointment times and durations designated for a given provider on a given day. This schedule-based framework also provides access to granular data such as timing of same-day cancellations relative to the appointment time, which can then be leveraged to quantify the potential for recovery of cancelled appointments and thus enhance access and revenue that would otherwise be lost.

With the goal of expanding the options for evaluation of clinic performance, this study introduces a system of schedule-based analysis that yields (1) metrics that quantify availability, scheduling, and appearance; and (2) a method to assess 'recoverability' of cancelled appointments. To gauge their feasibility and consistency, these concepts are applied to 18 months of data from a single cardiologist's clinic using cross-sectional and longitudinal analyses. To assess their ability to quantify the response to an operational change, the metrics are used to evaluate the impact on efficiency of moving a different cardiologist's clinic to a new physical location.

2. Methods

The study was approved by the Vanderbilt Medical Center Institutional Review Board.

2.1. Primary data

Archived digital rosters of the author's (KM) weekly (Monday) outpatient cardiology clinic from July 2015-December 2016 served as the primary data for this study. These rosters include appointment times, patient arrival times, type of visit (return vs new), and a notation if/when the appointment was cancelled on the day of the clinic. A sample clinic roster (with patient names omitted) is shown in Fig. 1. For appointments cancelled on the clinic day (i.e. the 12:30 and 13:45 appointments in Fig. 1), cancellation times were available by hovering over the associated entry in the 'Appt Notes' column. Clinic slots without a recorded arrival time and no notation of cancellation (i.e. the 09:45, 10:00, and 10:45 appointments in Fig. 1) indicated that the patient did not appear for the appointment and did not communicate with the clinic about the lack of attendance.

For most clinics, the schedule had unique slots available every 15 min from 8:30 AM to 2:45 PM, for a total of 26 slots per clinic. The main source of variation in availability was whether the author (KM) was rounding in the hospital on a given clinic day; if that was the case, clinic slots were closed until 10 AM, resulting in a reduction in availability to 20 slots per clinic. Regardless of the availability for a given clinic, return patients were scheduled in 1 slot (15 min) and new patients were scheduled in 2 slots (30 min). Slots that were available, but in which there was no patient scheduled (i.e. the 11:15, 11:30, 11:45 appointments in Fig. 1) were included in the number of available slots for each clinic; the availability of these slots was confirmed by separate dedicated scheduling software.

The 'intervention' dataset was derived in a similar manner from a different cardiologist's weekly (Wednesday) clinic at the same institution. Typically, that provider's schedule had unique slots available every 20 min from 8:40 AM to 11:20 AM and 1:20 PM to 3:40 PM, for a total of 17 slots per clinic. The change in the clinic's physical location (the intervention) occurred independently of this study and was a fortuitous 'natural experiment', rather than a prospectively planned transition. The clinic moved to an off-campus site several miles away, which houses multi-disciplinary offices affiliated with our Medical Center. The new location resulted in different medical assistants working in the clinic, but all other aspects of the clinic's operations remained the same. This change in location occurred at the very beginning of February 2017. Metrics from the first 4 months in the new location (February-May 2017) were compared to the analogous 4 month period in the prior location from 1 year ago (February-May 2016), and to the 4 months in the prior location immediately preceding the move (October 2016-January 2017). Comparisons were done using the two-tailed Mann-Whitney *U* test for non-parametric distributions (GraphPad Prism, version 7.02–San Diego CA); $p < 0.05$ was taken to be statistically significant.

2.2. Definition of 'optimal' number of clinic slots

If a clinic roster was completely efficient, the number of available slots would be identical to the number of slots required by the patients that actually appeared for that clinic. This scenario implies optimal availability (i.e. the exact right number of slots were eligible to be scheduled), ideal scheduling (all available slots had patients assigned to them), and perfect attendance (all scheduled patients appeared for their visits). Alternatively, this figure can be conceptualized as the number of slots that would have been designated for a given clinic had the 'outcome' of that clinic been known beforehand.

This theoretical number of slots can be calculated for a given clinic (or series of clinics) and is derived from the weighted sum of patients that appeared for the clinic of interest. If, as above, return patients are assigned 1 slot and new patients are assigned 2 slots, then this becomes:

Appt	Status	In Rm	L	Patient Name (MRN)	Actions	VOOM	Age	S	Type	Echo	StrE	EKG	Holt	Nucl	Vasc	Devc	Tred	Labs5	Provider	Rdy	Appt Notes
08:30	ar 09:06	28 min	E		Actions	1	65y	M	Return P	--	--	D*	--	--	--	--	--	--		--	mp Reason for visit: CAD, CHF w/ need for
08:45	ar 08:50	33 min	E		Actions	0	70y	M	Return P	--	--	--	--	--	--	--	--	D		--	mp 4 month follow up
09:00	ar 08:35	93 min	E		Actions	4	24y	F	New Pati	O*	--	D*	D*	--	--	O*	--	D*		--	mp Reason for visit: SOB, dizziness and hea
09:30	ar 09:42	6 min	E		Actions	1	59y	F	Return P	--	--	--	--	--	--	--	--	--		--	jm 4 mth fuv from 7/18/16
09:45		--	E		Actions	1	58y	M	Return P	O*	--	--	--	--	--	--	--	--		--	NO SHOW
10:00		--	E		Actions	0	75y	M	Return P	--	--	C*	--	--	--	--	--	--		--	NO SHOW
10:15	ar 10:09	-34 min	E		Actions	1	73y	F	Return P	--	--	--	--	--	--	--	--	--		--	jm 3 mth fuv from 8/8/16
10:45		--	E		Actions	--	57y	F	Return P	--	--	--	--	--	--	--	--	--		--	NO SHOW
11:00	ar 10:52	-67 min	T		Actions	0	71y	F	Return P	--	--	--	--	--	--	--	--	D		--	3 month follow up
12:00	ar 11:33	16 min	E		Actions	0	72y	M	Return P	--	--	--	--	--	--	--	--	--		--	jm 12 mth fuv from 11..09.15
12:15	ar 11:04	-97 min	E		Actions	0	82y	M	Rtrn-Vuh	--	--	D*	--	--	--	--	--	--		--	jm Diagnosis: Hospital d/c follow-up
12:30	CANCEL	--	E		Actions	--	69y	M	Return P	--	--	--	--	--	--	--	--	--		--	Cancelled - patient request
12:45	ar 12:42	-9 min	E		Actions	0	89y	F	Return P	--	--	--	--	--	--	--	--	--		--	eg 2 month follow up
13:00	ar 13:02	-203 min	E		Actions	1	85y	F	Return P	--	--	--	--	--	--	--	--	--		--	mb 2 month f/u apppt
13:15	ar 12:16	-282 min	E		Actions	3	85y	M	Return P	--	--	D	--	--	--	D*	--	D*		--	mp 6 month follow up from 5-16-16
13:30	ar 10:05	-223 min	E		Actions	3	62y	M	Return P	D*	--	--	--	--	--	--	--	--		--	mp 2D Echo per '/ I31.3 Order in V
13:45	CANCEL	--	E		Actions	1	82y	F	Return P	--	--	--	--	--	--	--	--	--		--	Cancelled - patient request
14:00	ar 13:33	-244 min	E		Actions	1	63y	F	Rtrn-Vuh	O*	--	D*	--	--	--	--	--	--		--	jm Diagnosis: Acute systolic heart failur
14:15	ar 13:51	-289 min	E		Actions	1	89y	M	New Pati	--	--	D*	--	--	--	--	--	--		--	jm Reason for visit: Establishing Cardiology S
14:45	ar 14:38	-307 min	E		Actions	1	75y	M	Rtrn-Vuh	--	--	--	--	--	--	--	--	--		--	mb Diagnosis: Nstemi

Fig. 1. Sample clinic roster. Key features include appointment slot times (in the leftmost column), patient arrival times (verification of appearance at the appointment), type of visit (return vs new), and a notation regarding cancellation. If the appointment was cancelled, hovering over the corresponding row in the 'Appt Notes' column (when actively using the electronic medical record) provides the time at which the cancellation occurred.