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Original contribution

Tardiness of starts of surgical cases is not substantively greater when the preceding surgeon in an operating room is of a different versus the same specialty

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A B S T R A C T

Study objective: Switching from one specialty to another increases mean turnover times (i.e., interval between the exit and entrance of consecutive patients in an operating room [OR]). We estimate the effect on the mean tardiness of to-follow surgeons from following another surgeon of a different versus same specialty. Tardiness of a case's start time refers to the number of minutes the patient enters the OR later than scheduled; tardiness is 0 min if the patient enters early. Tardiness cause surgeon waiting. There are multiple causes of tardiness, but, most often, the preceding case(s) took longer than estimated.

Design: 10-year historical cohort study with all surgical cases performed during regular workdays.

Setting: Large teaching hospital.

Measurements: Estimated OR end times were calculated using a Bayesian method. Because tardiness is influenced by the estimated case start time (i.e., later starting cases have greater tardiness), tardiness values were adjusted to a 12 noon start time for the 2nd surgeon.

Main results: The cases of to-follow surgeons in ORs had mean tardiness of 45.1 (SE 0.6) min. When the to-follow surgeon in the OR was of a different versus the same specialty from the first surgeon, the mean turnover time was 7.3 (0.4) min longer ($P < 0.00001$). However, the mean tardiness was not significantly affected (0.1 min, 95% confidence interval [CI] −2.7 to 3.0 min; $P = 0.93$). In comparison, if one or more of the preceding cases in an OR was an add-on case, the increase in mean tardiness was 35 min (95% CI 28 to 43 min; $P < 0.00001$).

Conclusions: OR managers can assure surgeons with afternoon starts that following a surgeon of a different specialty generally will not increase their waiting time. Case scheduling should focus on reducing over-utilized OR time and thus the hours that anesthesiologists and nurses work late.

1. Introduction

Theoretically, the easiest way to reduce the time surgeons wait beyond their scheduled start time would be for all surgeons to have first-case starts [1]. However, this is not practical because there are many more surgeons than operating rooms (ORs) at most hospitals and growth occurs from low-caseload surgeons [2,3]. For example, most (77.3%) surgeons' lists (i.e., series of cases in same OR on same day) in Iowa in 2013–2015 included only 1 or 2 cases, consistent with a US national benchmarking study reported in 1998 [4,5]. Unless there is substantial underutilized OR time, each surgeon will not have a first case start. This is inconvenient for the surgeon and the patient because cases that are not the first case of the day often start late, and sometimes much later than scheduled [1].

Tardiness of a case's start time refers to the number of minutes the patient enters the operating room (OR) later than scheduled, but is calculated as 0 min if the patient enters early or at the scheduled time [1]. A synonym for tardiness is the surgeon's waiting time [6]. There are multiple causes of tardiness (e.g., add-on case in the OR before the to-follow surgeon in the OR). The cause of some patients' and surgeons' waiting is that the preceding case or list of cases took longer than estimated [1,7,8]. A “2nd surgeon” or “to-follow” surgeon is defined as the primary surgeon of cases that start after a different primary surgeon finishes his or her cases in the same OR.

The most quantitatively effective and practical strategy to reduce daily OR tardiness is to incorporate the mean lateness of start of the first

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case of the day and any bias in estimated OR times when calculating start times [8]. This approach has a large overall benefit because it influences start times of all cases that are not first cases of the day [8]. However, even once implemented, substantial tardiness of starts for to-follow surgeons in ORs can remain. The residual tardiness can reduce the productivity of to-follow surgeons because those who regularly arrive to the OR in time for the scheduled start time will have greater values for the denominator of the productivity equation (e.g., relative value units of the procedures performed/their time to perform the cases).

Generally, starting each to-follow surgeon's cases earlier in the day results in less tardiness because tardiness is cumulative, other than when cases can be moved among ORs [1,8]. Tardiness also can be reduced by scheduling to-follow surgeons in those ORs without cases with substantial uncertainty in OR times (e.g., > 1:3 chance of taking 1 h longer than estimated) [9–12]. However, both of these interventions can be constrained by safety and practicality (e.g., an available OR may be of inadequate size to perform a robotic case). In addition, the otherwise ideal choice of the OR may have a preceding surgeon scheduled to be performing a different class of procedure [13]. What is unknown is whether cases tend to start later than scheduled more often when a transition from one surgeon to another involves a change of specialty.

A study of turnover times by Austin et al. suggested that switching from one specialty to another may be associated with small delays in starting cases [13]. These authors found that when switching from one surgeon to another, turnover times were increased [13]. The incremental effect of the class of procedures also changing was a further increase in mean turnover times [13]. Doll et al. similarly reported longer turnover times, and, thus, this observation likely is generalizable [14]. However, the consequences of these findings on tardiness of starts are unknown. Since tardiness of starts depend also on case duration estimation and scheduler behavior, the contribution of longer turnover times to tardiness has not, to our knowledge, previously been quantified [1].

In our study, we used 10 years of data analyzed by year to estimate the effect on the total tardiness of to-follow surgeons when a surgeon of a different specialty follows another surgeon.

2. Methods

This study was approved by the Thomas Jefferson University Institutional Review Board with a waiver of informed consent.

2.1. Data analyzed

There were 233,428 cases scheduled i) as of 7:00 PM the day before surgery or listed as an add-on case, ii) with a date of surgery that was a Monday to Friday, January 1, 2007, through December 31, 2016, and iii) to be performed at one of Thomas Jefferson University Hospital's surgical suites or the Jefferson Surgery Center. Cases were considered add-on if not planned to be performed on the date of surgery as of 7:00 PM of the day before surgery, including not previously scheduled (e.g., trauma). Excluded were obstetric and non-operating room cases (e.g., cases performed at the hospital-based endoscopy center). Both the hospital surgical suite and hospital outpatient department were included to have wide ranges of turnover times and case durations included.

The OR scheduling system database scheduling and audit tables (ORSOS, McKesson, San Francisco, CA) were used to obtain the following scheduled data of each case as of 7:00 PM the day before surgery: surgeon, procedure(s), OR, start time, and end time. Estimated OR end times were calculated using the Bayesian method implemented at the hospital (below) [15,16].

The 233,428 cases from ORSOS were matched to the corresponding cases in the anesthesia information management system (Innovian, Dräger, Telford, PA).[4] The actual location and the times of OR entrance and exit were determined from Innovian if a matching anesthesia record was found [17–19]. Otherwise, the corresponding data from ORSOS were used. Cases were considered as cancelled after 7:00 PM on the day before the scheduled date of surgery if a delete date was present after this time in ORSOS and there were no timestamps indicating that the cases had entered or left the OR on the date of surgery.[4]

Among the 233,428 scheduled cases, there were $N = 15{,}803$ cases that met the following criteria: i) scheduled to start 10:00 AM to 2:00 PM; ii) performed by a surgeon different from the surgeon of 1 or more cases scheduled or performed in the same OR earlier that day; and iii) not performed on a weekend, federal holiday, or date of a local federally declared disaster. Table 1 summarizes these 15,803 studied cases. The start times were 8:30 AM on Thursdays and 7:15 AM otherwise. We chose 10:00 AM as being the start of the middle of an 8-hour workday and 2:00 PM as being near the end of the middle of a 10-hour workday.

In addition to the 15,803 performed cases, 28,600 cases met one of two criteria. The first criterion was that the case was scheduled as of 7:00 PM the day before surgery to have been performed earlier on the same day and in the same OR as one of the 15,803 cases. The second criterion was that the case was performed earlier on the same day and in the same OR as one of the 15,803 cases but starting after the beginning of the regular workday (i.e., an add-on case, but not one performed from 1:00 to 4:05 AM). Table 2 describes these 28,600 cases.

The total number of cases studied was 44,403, where 44,403 = 15,803 + 28,600. These 44,403 cases were performed or were scheduled to have been performed in 36 ORs, each with 288 to 3218 cases; median 1027, interquartile range 713 to 1567 cases.

2.2. Estimated case durations

At the studied surgical suites, estimated OR times were calculated using a Bayesian method [19]. Consequently, this study's methods are reproducible. An example of a non-reproducible method would have been to neglect historical data of how long cases took and just use each surgeon's estimate. The rest of this section describes in detail how case durations were estimated.

Bayesian methods increase the accuracy of estimation of OR time for case scheduling [9,11,12,16,20–24]. The surgeon's estimate (i.e., prior knowledge) is combined with whatever historical data are available [16]. Inferences are made based on the joint information (i.e., the posterior probability distribution). When there are few historical OR times of the same combination of surgeon and scheduled procedures (e.g., $0 \leq n_k \leq 3$), the information relied upon is principally the surgeon's estimate [20–24]. When there are many data (e.g., $n_k > 19$), the surgeon's estimate is included, but negligibly influences the value used for case scheduling [16].

The Bayesian method used was based on the two-parameter log-normal distribution centered at the surgeon's estimate of the median OR time [9,11,12,16]. Tables for the Bayesian method were updated at the end of each year and used for the following year's calculations. Specifically, for each combination of suite and year, the parameters α and β were estimated using inverse gamma distributions, as described in Reference [9]'s Fig. 1 and Eq. (13), and in Reference [15]'s Appendix 2.

The statistics calculated and stored annually for the kth combination of surgeon and scheduled procedure(s) were the number of cases (n_k), sample mean of the natural logarithm of the OR times in minutes ($\overline{x_k}$), and the sample variance of the log OR times. If there were > 99 historical OR times from all preceding years of data for the combination of

[4] For 3 cases, there was no delete date but also no evidence that the cases had been performed. These cases were inferred as having been cancelled before 7:00 PM on the day before the scheduled date of surgery. These 3 cases are not included among the 233,428 cases.