Improving On-Time Start of Day and End of Day for a Pediatric Surgical Service

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KEY WORDS
quality improvement, child, operating rooms

ABBREVIATIONS
CCHMC—Cincinnati Children’s Hospital Medical Center
ENT—ear, nose, and throat
IR—induction room
IT—information technology
OR—operating room
PACU—postanesthesia care unit
QI—quality improvement
SDS—same-day surgery

Dr Varughese helped design the improvement project and analyze the data, drafted and wrote the initial manuscript, and revised the manuscript; Dr Adler helped design the improvement project, analyze the data, and draft the initial manuscript; Ms Anneken designed the data collection instrument, analyzed the data, and critically reviewed the manuscript; Dr Kurth helped design the improvement project and critically reviewed the manuscript; and all authors approved the final revised manuscript.

www.pediatrics.org/cgi/doi/10.1542/peds.2012-2820
doi:10.1542/peds.2012-2820

Accepted for publication Feb 14, 2013

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).
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FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

abstract

BACKGROUND AND OBJECTIVE: In multicase pediatric ear, nose, and throat operating rooms (ORs), brief delays in early case start times often produce a cascading effect of lengthy delays by the end of the day and can often lead to patient, family, and staff dissatisfaction and increased labor costs due to unplanned overtime. We sought to improve actual end of day relative to scheduled end of day from 40% to 60%.

METHODS: Key drivers of the process included case scheduling, ordering of sedative medications, and nurse availability in the postanesthesia care unit to receive the patient from the anesthesia provider. A multidisciplinary team conducted a series of tests of change addressing the various key drivers. Data were collected by using an independent, impartial data collector as well as being extracted from the hospital information technology system. Data were analyzed by using control charts and statistical process control methods.

RESULTS: The percentage of ORs ending on time increased from 40% to 60%. Appropriate scheduling of complex cases increased from 10% to 87%, and accurate scheduling of case duration improved from 21% to 48%. Timely premedication increased from 55% to 90% and immediate availability of a nurse in the postanesthesia care unit from 68% to >90%.

CONCLUSIONS: By applying quality-improvement methods, significant improvements were made in a multicase pediatric ear, nose, and throat OR. The impact can be significant by reducing wait times for patients, as well as staff overtime for the institution. Pediatrics 2013;132:e219–e228
Scheduling of multiple cases in an operating room (OR) and adhering to the schedule present many challenges for pediatric surgical services. Pediatric surgical services typically contain a series (list) of 10 to 20 children undergoing brief procedures. The total time for scheduling a case includes operative and nonoperative time. The latter includes time for anesthesia induction and emergence, patient transport to the recovery room, and room clean-up and set-up for the next case. This nonoperative time often exceeds the operative time. Brief delays with each case accumulate into lengthy delays by the end of the day, which dissatisfy patients, parents, and staff.

At Cincinnati Children’s Hospital Medical Center (CCHMC), the pediatric ear, nose, and throat (ENT) surgical service represents a prototypical, brief-procedure, and throat (ENT) surgical service replication. As a tertiary care facility for Cincinnati and tertiary care facility for southern Ohio, northern Kentucky, and southeastern Indiana, CCHMC’s surgical services performed ~32,000 cases in fiscal year 2010, of which the pediatric ENT surgical service conducted ~40% of all the cases, in 6 ORs.

Methods

Ethical Considerations

This QI project had no direct contact with patients or families and was considered nonhuman subjects research. Data were obtained from the hospital information technology (IT) system (EPIC).

Setting

The project was conducted at CCHMC, a 530–medical and surgical bed, urban, pediatric academic medical center, and the primary care facility for Cincinnati and tertiary care facility for southwestern Ohio, northern Kentucky, and southeastern Indiana. CCHMC’s surgical services performed ~32,000 cases in fiscal year 2010, of which the pediatric ENT surgical service conducts ~40% of all the cases, in 6 ORs.

Improvement Team

The QI team consisted of 1 ENT surgeon, 2 anesthesiologists, 2 ENT surgical nurses, 2 nurses from the same-day surgery (SDS) clinic and the post-anesthesia care unit (PACU), and 1 surgical scheduler. More than half of the team had received formal QI training. A QI consultant, data analyst, and IT specialist provided technical support.

Planning the Interventions

The project was conducted in 3 overlapping phases from January 2008 to June 2009, during which pilot data were collected and key drivers and interventions for improvement were developed and implemented. During the first phase (phase of observation and discovery, January 2008–March 2008), the QI team interviewed pediatric ENT surgeons, anesthesiologists, and nurses to determine the cause of the delays. Because after the interviews each discipline harbored firm opinions on the cause of delays, the team decided to collect pilot data to determine the actual cause of the delays using an independent impartial data collector not affiliated with the perioperative area.

Data were collected by using standardized definitions as developed by the team (Table 1). A delay occurred when the actual time lagged the corresponding scheduled time. Causes for delay were categorized after consensus from all providers involved with the case. Delay categories included patient arrival, preparation by anesthesia (eg, premedication order), nursing (eg, assessment), or surgeon (eg, consent and site marking), OR (eg, equipment, anesthesia, nursing or surgeon unavailability) and PACU (eg, patient related, nurse availability) (Supplemental Appendix A). Pilot data were collected for 2 weeks, in 1 ENT OR over 2 separate months. Only elective scheduled cases were included in the data collection because emergent cases occurred in a separate OR as a separate flow stream with other OR staff.

During the second phase (phase of intervention design and implementation, February 2008–December 2008), the team identified operational factors or key drivers and their associated interventions believed to reduce delays from the pilot data (Fig 1). The team set a goal for the ENT ORs to end the day on time, as scheduled, on 60% of days by July 2009. The goal was established from baseline end of day on time at 40% and institutional benchmark data for
non-ENT pediatric surgical services achieving at least 60% end of day on time.

**Key Drivers and Interventions**

**Scheduling**

In this key driver, delays originated from inaccurate (case time) scheduling as a result of variations in patients’ coexisting disease and in operating speed among surgeons. To address the issue of patient-related variation, patients were classified as either class I (less complex) or class II (more complex). The anesthesiologists in the team developed a list of class II patients, or factors that affect procedure time, such as patients with muscular dystrophy and malignant hyperthermia requiring intravenous induction and patients with complex congenital cardiac disease (Supplemental Appendix B). Class II patients with these comorbidities were allotted 15 minutes additional case time in scheduling. An electronic scheduling system (EPIC) provided case average duration by individual surgeon. Average case duration was calculated from the last 10 cases performed by a particular surgeon for a given procedure.

**Standardization of Processes**

A second key driver was variability in the processes of patient care among providers, especially in the SDS clinic. Patients were scheduled to arrive in the SDS clinic 90 minutes before the case start time. After the SDS clinic nurse assessment, an anesthesiologist evaluated cases with assistance by a certified registered nurse anesthetist for the first cases and a nurse practitioner for subsequent cases. For cases to start

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**TABLE 1 Definition of Target Times**

<table>
<thead>
<tr>
<th>Target Time</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient in SDS</td>
<td>Time patient is placed in an SDS room</td>
</tr>
<tr>
<td>Anesthesia assessment in SDS start</td>
<td>Time the preoperative assessment is started by anesthesia</td>
</tr>
<tr>
<td>Patient ready or chart closure</td>
<td>Time when all preparations required before transport</td>
</tr>
<tr>
<td>(assessments complete, consent)</td>
<td>are complete</td>
</tr>
<tr>
<td>Arrive in SDS for patient pick up</td>
<td>Time team arrives in the SDS room to pick up patient</td>
</tr>
<tr>
<td>Leave SDS for OR</td>
<td>Time team leaves with patient for the OR</td>
</tr>
<tr>
<td>OR start or wheels into OR/induction room (IR)</td>
<td>Time patient enters OR/IR</td>
</tr>
<tr>
<td>Anesthesia start</td>
<td>Time when mask is placed on patient’s face (inhalational induction) and time when intravenous (IV) line placement is started (IV induction)</td>
</tr>
<tr>
<td>Anesthesia ready</td>
<td>Time when anesthesia states “ready” (airway secured, IV line secured, monitors on)</td>
</tr>
<tr>
<td>Surgery start</td>
<td>Time surgeon conducts “time out” in the OR, all team members present ready to perform procedure</td>
</tr>
<tr>
<td>Surgery end</td>
<td>Time surgeon leaves or drapes are removed and dressings are in place</td>
</tr>
<tr>
<td>Patient out of OR</td>
<td>Time team leaves to travel to next patient location</td>
</tr>
<tr>
<td>Arrive in PACU</td>
<td>Time team arrives with patient in PACU</td>
</tr>
<tr>
<td>PACU nurse arrival</td>
<td>Time when PACU nurse arrives at bedside</td>
</tr>
<tr>
<td>Anesthesia finish</td>
<td>Time anesthesia completes hand-off and team leaves bedside</td>
</tr>
<tr>
<td>Arrival of team in OR</td>
<td>Time team arrives in OR to start next case</td>
</tr>
</tbody>
</table>

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**FIGURE 1**

Key driver diagram for the improvement project presenting the project aim, theories (key drivers), and ideas for change (interventions).
on time, an order prescribing a sedative or not had to be entered into a computerized system at least 25 minutes before the start time for first cases and 45 minutes for subsequent cases, as well as completion of nursing and anesthesia assessments and surgical consent and site marking 10 minutes before case start. In June 2007, 6 months before the initiation of this improvement initiative and during an independent improvement project, the anesthesia staff had implemented a computerized order entry system for the first case of the day and facilitated its success by changing 3 work processes. The first process was to obtain key information at the beginning of the preanesthesia evaluation rather than at the end to enable an early decision for sedative premedication. The second was to use a clinical algorithm to facilitate this early decision. The third was to eliminate the routine prescription of acetaminophen for postoperative pain relief to be administered preoperatively in the SDS clinic. A literature search did not provide evidence to support the use of acetaminophen for this purpose. Success with premedication order entry for first cases continued to be monitored for sustainability with the changes implemented. Subsequently, in April 2008, after initiation of the current improvement initiative, these work processes were spread to all subsequent cases in the day. With the implementation of the EPIC IT system in July 2008, these changes in work processes for both first and subsequent cases were reinforced. To facilitate compliance with these changes, all anesthesia providers were reeducated and compensation was tied to success.

Effective Communication
A third key driver was the ineffective communication between the SDS clinic, OR, and PACU clinical providers with regard to patient readiness and flow. An intervention discussed with the various groups and then tested on a small scale was the optimization of the electronic OR status board to indicate patient readiness and status of key processes such as completion of surgical and anesthesia consent and administration of sedative premedication. The QI team worked with the EPIC specialists to develop and standardize status board icons to represent these key events and ensure that all teams were able to view the same status board. All perioperative staff were then educated and trained in these modifications to the electronic status board.

Resource Alignment
Last, the team examined staffing for anesthesia nurse practitioners in the SDS clinic and nurses in the PACU relative to surgical caseload. Staff deficiencies existed at peak caseloads during midmorning and lunch periods. The team representatives from the SDS clinic and PACU worked to forecast staffing and changed staff shifts to match the caseload.

Study of Interventions
During the third phase (phase of study of interventions, April 2008–June 2009), the team assessed how well the interventions were implemented and their impact on the goal. To evaluate the scheduling of patients by disease complexity, the anesthesiologists conducted audits to check the appropriate scheduling of class I and II patients. After implementation of the EPIC electronic scheduling system, a comparison was made of the scheduled procedure duration with the actual duration of the procedure to monitor the accuracy of scheduling by surgeon and type of procedure. The surgeon representative on the team provided individual feedback on success with appropriate and accurate scheduling to the ENT surgeons on a monthly basis.

To assess the implementation of the sedative premedication order process, the IT specialist developed an electronic report that captured the percentage of patients for which timely premedication occurred. Timely premedication for first cases was defined as order entry before 7:05 AM for a 7:30 AM start and for subsequent cases as 45 minutes before the scheduled OR time. The report included specific provider information, which was used to provide individual feedback to the anesthesia providers. Delays associated with pending surgical consent and site-marking that delayed chart closure were used to provide individual feedback to the ENT surgeons.

After changes in both SDS nurse practitioner and PACU nurse staffing shifts were implemented, the impact on the SDS and PACU processes was assessed. On a monthly basis, the QI team reviewed all qualitative and quantitative reports, and the information with graphic displays was conveyed to perioperative staff through monthly meetings, memos, and poster boards.

Methods of Evaluation and Analyses
All time data were automatically abstracted from the electronic medical record. As with the pilot data collection, only elective scheduled cases were included. The primary outcome measure was the proportion of ENTORs ending on time (within 30 minutes of scheduled end time) with a goal of 60%. Secondary outcome measures included (1) the proportion of patients scheduled with appropriate procedure time based on disease complexity with a goal of 80%, (2) the proportion of patients in whom actual case duration did not exceed scheduled case duration (goal 40%), (3) the proportion of premedication orders entered on time (goal ≥90%), and (4)
the proportion of patients in whom
the nurse was available on arrival
to the recovery room (goal ≥90%).
Two balancing measures monitored
during the improvement project were
the proportion of children exhibiting
distress on induction using the in-
duction compliance checklist score
and the number of ENT cases con-
ducted per week. The induction com-
pliance measure, collected as part
of the anesthesia quality assurance
program, ensured that while changes
were being made to the premed-
ication order entry process, children
who met criteria received premed-
ication.8 The numbers of cases con-
ducted per week were monitored to
ensure that while scheduling changes
were being made, the volume of cases
did not decrease.

Data obtained from automatic elec-
tronic reports were analyzed each week
using proportions. Statistical control
charts were developed for primary
and secondary measures and pre-
sented to the QI team on a monthly
basis. Upper and lower control limits
(±3 σ) were applied to assess statis-
tical process control. These charts
helped to display and analyze variation
in the time-series data. Variation was
identified as common-cause variation
(data points within upper and lower
control limits) or special-cause varia-
tion and used to evaluate the effec-
tiveness of the interventions. Special
cause was considered with the pres-
ence of any of the following criteria: (1)
a “shift” of the mean or center line
from ≥8 consecutive points below or
above the center line (data points on
the center line are not included), along
with knowledge of when interventions
occur; (2) a “trend” from 6 consecu-
tive data points in either direction; (3)
“alternating points” with 14 consecu-
tive data points alternating above and
below the center line; or (4) a data
point outside of the upper and lower
control limits. Because we had a
number of measures to assess all
aspects of the processes, we also de-
veloped a dashboard to assess all
aspects of the processes, we also de-
veloped a dashboard to obtain a quick
snapshot of the results (Supplemental
Appendix C).

RESULTS
In phase 1, the majority of the delays
resulted from incorrect scheduling of
cases (51%). Of the SDS clinic delays
(35%), the majority originated from late
sedative premedication order (51%). Of

![System Outcome Measure](image-url)

**FIGURE 2**
Control chart presenting the percentage of cases ending on time in multicase ENT operating rooms. The solid red line represents the average percentage of cases ending on time. The dotted red lines represent upper and lower control limits, which correspond to ±3 σ from the mean. Special cause is shown by the two “shifts” of the mean above the center line.
the PACU (14%) delays, nurse availability accounted for 100% of the delays. At baseline, 40% of ENT ORs ended the day on time. After 18 months and the end of phase III, the proportion increased to 60% (Fig 2). The first improvement occurred during the first 8 months and was the result of nurse practitioner staffing adjustments in the SDS clinic to improve the timely premedication process and appropriate scheduling taking into account patient complexity. The next significant improvement occurred after the change from case-specific time to surgeon and procedure-specific scheduling time and the staffing changes in the PACU. Appropriate scheduling based on patient complexity increased from 10% at baseline to 87% after 18 months. The proportion of actual surgical case duration meeting the scheduled case duration increased from 21% at baseline to 48% and was attributed to the electronic scheduling system (Fig 3). As a balancing measure to monitor productivity, the average weekly number of cases conducted before the project, after implementation of the scheduling changes, and after the project ended, were collected. The number of cases per week before, during, and after the project were 153, 167, and 155, respectively.

Figures 4 and 5 present the standardization of the sedative premedication order process in SDS clinic. Success declined in August 2008 after implementation of a new electronic medication order entry system (EPIC) but returned to preimplementation levels within 3 months after clinicians learned the new system. Success with timely sedative premedication order entry for subsequent cases increased from 20% to 85%. Although the goal was not quite achieved, variability was reduced. No changes were noted during the study period in the proportion of children exhibiting distress during the induction of anesthesia (balancing measure).

Figure 6 presents the success with a PACU nurse availability, which increased to >90%, with data points outside of the control limits indicating special cause. In September 2008, after an analysis of staffing patterns and patient flow into the PACU, modifications were made to the number of staff available during high patient volume periods. This intervention resulted in a sustained increase with this measure over time.

**DISCUSSION**

Increasing productivity by reducing waste has become a key focus for
hospitals. Multicase ORs such as pediatric ENT ORs often experience cascading delays that waste time and productivity as well as dissatisfy staff and families. Our system experienced waste due to the unplanned overtime and associated labor costs related to these ORs running late. Our work addressed this waste by improving the success of our multicase pediatric ENT ORs ending on time to 60%. QI methods can be used successfully to reduce variability in perioperative care processes and improve OR efficiency. Our results support this and demonstrate that it is possible to identify important key drivers, set goals for OR performance, and apply QI methodology to make significant improvements.

Key drivers to reduce delays and waste of time were reliable scheduling, standardization of care processes, effective team communication, and alignment of nurse staffing resources with case volume. Overdyk et al found that meaningful improvements in OR efficiency can occur through multidisciplinary efforts of surgeons, anesthesiologists, and nurses, with accountability by each discipline being critical. Our conclusions are similar, as success required collaboration among our ENT surgeons, schedulers, anesthesiologists, nurse practitioners, and nurses in the SDS clinic, OR, and PACU. In a study of OR start times and turnover times in a university hospital, Mazzei found each discipline had different perceptions of the cause for delays. Our study confirmed this finding. To address this problem, the QI team adopted many of the definitions by the Anesthesia Association of Clinical Directors. Overdyk et al recognized the importance of impartial data collection to exclude bias from data collected by a particular discipline even though nurses were used to collect data without verification from anesthesiologists or surgeons. Our study used a data collector independent of the provider disciplines to record the cause of delays confirmed by consensus from surgeons, anesthesiologists, and nurses involved in the case.

In the previous study, Overdyk et al found that the reasons for delays were surgeon unavailability to start case (9.4%), patient arriving to the hospital late (6.8%), surgical consent not done on time (5.4%), anesthesiologist’s unavailability to start case (5.4%), and anesthesia assessment not done on time (4.1%). In contrast, our main delay cause was related to inaccurate scheduling of case duration, in that...
cases took longer in the OR due to insufficient allocated case time and patient complexity. Variability in processes in SDS clinic (anesthesia assessment and premedication order entry not being done on time) and PACU nurse unavailability to receive patient accounted for most of the remainder of delays. Surgeon and anesthesiologist unavailability and surgical consents were uncommon reasons for delays with the ENT surgical service in our institution. Additionally, because, in our setting, brief procedure, multicase ORs require minimal housekeeping and equipment setup between cases, room turnover was not found to be a reason for delay.

We believe the changes made to OR scheduling were instrumental in making significant progress toward the end-of-day goal. A recent study by Wright et al suggests that OR scheduling accuracy may have a greater impact on improving OR efficiency than other methods addressing personnel performance and protocols. Several authors have studied various predictors of OR case durations. Zhou et al found that relying solely on historical data to estimate surgical case duration times is an ineffective technique for reducing delays and end-of-day time. Inaccuracy with this technique arises from insufficient previous case numbers to estimate and the imprecision associated with half the predicted cases taking longer than expected and the other half taking less time than predicted. Instead, the use of surgeon and procedure-specific data with type of anesthesia and use of individual patient comorbidities or risk factors have been shown to improve the prediction of OR case durations.

We used both surgeon-specific historic average procedure duration and individual patient risk factors to predict case duration.

Another factor instrumental in making significant progress toward the end-of-day goal was the alignment of PACU staffing with the caseload. Dexter describes the reasons why PACU staffing is difficult to predict and not analogous to nurse staffing on the ward, in the emergency department, or in a clinic. Unlike the ward, PACU workload varies markedly and is more peaked by time of day. In a clinic, unlike in the PACU, patients sit in a waiting area or holding area before being seen, and in the emergency department, staffing is not planned with the goal of having a zero wait for the admissions of all patients. Because we identified consistent daily deficiencies in nurse
staffing during high peak periods such as midmorning and lunch periods, shifts were altered to increase the number of nurses available during these times.

Several local factors enabled the success of this improvement project. First, an infrastructure for process improvement, consisting of QI consultants, data collectors, and analysts and IT specialists exists within the organization of the Anderson Center. Our multidisciplinary team used this infrastructure and did not have to create it. Organizations lacking this infrastructure will need commitment on the part of leaders, to the improvement efforts, and to providing the necessary resources required for a project of this nature. Second, our project goal aligned with the vision and mission of the organization, namely, to improve OR efficiency and patient and family satisfaction. Third, the model for improvement using small tests of change or the plan-do-study-act methodology has been widely adopted within the institution. Improvement teams are encouraged to test changes on a small scale and learn from their successes and failures. Fourth, conducting next-day failure analysis by providing data on the impact of interventions, as well as practitioner-specific data on failures, facilitated rapid learning about the interventions and drove individual accountability. Dissemination of information by displaying run charts on OR poster boards and at monthly meetings reinforced the education on process change. Last, many of the team members had received QI training within the institution and have learned to practice improvement habits essential for effectiveness: viewing any clinical practice as a “process” that depends on many factors, reducing variation in health care, collaborative learning from others, and recognizing that improvement requires change.

There are limitations associated with this improvement work. First, our project focused on delays in multicase ORs with brief procedures and the results of the process improvements may not generalize to other services, such as long-duration neurosurgery or cardiothoracic surgical services in which patient complexity, equipment setup, and turnover play larger roles for delays. Second, we recognize that the early positive results achieved may be attributed in part to surgeon motivation.

FIGURE 6
Control chart of the percentage of cases with immediate availability of a nurse on arrival to the PACU. The solid red line represents the average percentage of cases with immediate availability of nurse on arrival. The dotted red lines represent upper and lower control limits, which correspond to ±3σ from the mean.
and to the Hawthorne effect, whereby practitioners modify their behavior because they are aware they are being studied. However, the improvement project was conducted over an 18-month period during which short-term behavior modifications due to the Hawthorne effect are difficult to sustain and improvement is more likely to result from system changes. Last, the improvement team addressed the issue of sustainability of the improvement work. Although the proportion of cases ending on time dropped to 50% in June 2009, data through December 2009 indicated that the improvement efforts were sustained at 60%. Possible explanations for the decreasing trend (only 7 data points below centerline so this is not considered a “shift”) are the presence of new faculty, residents, and fellows and the overall increased case volumes in the ORs typically observed during these months.

CONCLUSIONS
We identified a set of key drivers critical to improving efficiency and reducing cumulative delays in a multicase ENT surgical service. By applying quality improvement methodology, we were successful in improving patient flow and increasing the number of ORs ending on time through reliable scheduling, standardization of care processes, effective team communication, and resource alignment. Application of these system improvements across the entire perioperative process versus the application of isolated improvement work in select perioperative areas was critical to the success of this project. Although it is difficult to evaluate the relative impact of each of these improvements on the system, we believe reliable scheduling and resource alignment were the key factors leading to the improvements seen in our ORs ending on time. Our future work includes sustaining these improvements in the long term as well as introducing the work to other surgical services.

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*Pediatrics* 2013;132;e219
DOI: 10.1542/peds.2012-2820 originally published online June 24, 2013;

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DOI: 10.1542/peds.2012-2820 originally published online June 24, 2013;

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