Application of Lean Sigma to the Audiology Clinic at a Large Academic Center

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Abstract

Objective. To apply Lean Sigma—a quality improvement strategy to eliminate waste and reduce variation and defects—to improve audiology scheduling and utilization in a large tertiary care referral center. The project goals included an increase in utilization rates of audiology block time and a reduction in appointment lead time.

Study Design. Prospective quality improvement study.

Setting. Academic tertiary care center.

Subjects. All patients scheduling audiology clinic visits July 2013 to July 2014.

Methods. Value stream mapping was performed for the audiology scheduling process, and wasteful steps were identified for elimination. Interventions included a 2-week block release, audiology template revision, and reduction of underutilized blocks. Schedule utilization and lead time for new patient diagnostic audiogram were measured for 5 months postintervention and compared with 5 months preintervention. Overall, 2995 preintervention and 3714 postintervention booked appointments were analyzed.

Results. Block utilization increased from 77% to 90% after intervention (P < .0001). Utilization of joint-with-provider visits increased from 39% to 67% (P < .0001). Booked appointments increased from 2995 to 3714, with joint-with-provider booked appointments increasing from 317 to 1193. Appointment lead time averaged 24 days postintervention, compared with 29 days preintervention (P = .06). Average monthly relative value units measured 13,321 preintervention and 14,778 postintervention (P = .09).

Conclusion. Lean Sigma techniques were successfully used to increase appointment block utilization and streamline scheduling practices.

Keywords
Lean, Six Sigma, clinic efficiency, outpatient clinic, clinic performance

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Falling reimbursements have led to pressure to see increasing numbers of patients while maintaining high-quality care. With greater patient volumes, small inefficiencies can lead to noticeable delays and lost revenue, in addition to negatively affecting the patient experience. Lean Sigma is an increasingly popular method to improve quality and efficiency in the health care industry.

Lean Sigma is a combination of 2 methods used in industry to improve quality and efficiency: Lean and Six Sigma. Lean was developed by the Toyota Corporation to streamline its manufacturing processes. The application of Lean involves improving efficiency through eliminating waste across an organization by using one of a large variety of quality improvement tools. Value stream mapping is a popular Lean tool, and it involves creating a visual representation of every process step to enhance steps that add value for the consumer while eliminating wasteful steps. After analysis, the map is used to design a more streamlined system flow across multiple processes.

Six Sigma is a process improvement method conceived by the Motorola Corporation to improve quality by reducing variability. Ultimately, the application of Six Sigma aims to reduce the error rate of a process to ≤6 SDs from the process mean, or 3.4 defects per million instances. A 5-step analytic approach is used to refine operations: define, measure, analyze, improve, and control (DMAIC). Six Sigma uses more rigorous statistical analysis than Lean and aims...
to identify defects in a process through analysis of data via a variety of measurement tools.

Lean Sigma combines the statistical rigor of Six Sigma with the large waste reduction toolbox of Lean to create a powerful quality improvement tool. A major goal of Lean Sigma is to reduce waste and streamline workflow so that every process step adds value from the point of view of the customer. The implementation of Lean Sigma strives to eliminate steps in process that consume resources but do not add value to the customer.

This study aimed to improve audiology scheduling in a large tertiary care referral center through application of Lean Sigma concepts to eliminate waste and improve the patient experience. At our institution, the majority of new adult patients seen in the otology division needed audiograms, and approximately half of new pediatric patients needed audiograms. Prior to this project, faculty physicians frequently complained of difficulty scheduling new patients needing audiograms within a reasonable amount of time, leading to extended appointment lead times. At the same time, audiology scheduling was underutilized. Audiology appointments are grouped into predefined blocks of time reserved for certain patient categories. The project goals included increased utilization rates of audiology block time and reduced average appointment lead time.

**Methods**

Lean Sigma principles were applied to improve audiology clinic scheduling and utilization for a large outpatient tertiary care center. The Six Sigma DMAIC sequence was used as a framework. All stakeholders—including representatives from audiologists, call center employees, medical office coordinators, administrators, and physicians—were involved to facilitate a complete view of scheduling procedures. The multidisciplinary team met every 2 weeks throughout the process.

In response to anecdotal complaints from physicians and schedulers about the difficulty of scheduling audiograms expeditiously, the team reviewed the scheduling process. Types of audiology blocks included the following: patients requiring an audiogram in conjunction with an appointment with a physician, “open” blocks for any patient needing an audiogram, “tuck-in” blocks of appointments for urgent patients requiring same-day audiograms, and a block for patients participating in an executive health program run by the institution. Lead time was defined as the amount of time before the next available new patient audiogram appointment.

Scheduling data were obtained from the electronic medical record (Epic Systems). Appointment block utilization rates were calculated over a 5-month period and analyzed to identify underutilized blocks. After review of baseline data, the multidisciplinary team selected block utilization as the primary outcome measure, with total audiology relative value units (RVUs) and new appointment lead time as secondary measures. Identified defects included low appointment block utilization (77%) and long appointment lead time (29 days). The team proposed a primary project goal of increasing block utilization to ≥90%.

The multidisciplinary stakeholder team then performed value stream mapping for the audiology scheduling process. The map created by the group included steps from initiation of appointment request to successful scheduling of appointment. After creation of the visual representation of all steps, each step was reviewed, and inefficient or non-value-added steps were identified for elimination. All steps for which optimization was possible were targeted. Misalignment of physician clinic days and audiology joint-with-provider block time was evaluated.

Using data from value stream mapping and block analysis, the multidisciplinary stakeholder team discussed possible interventions and made a final selection based on group consensus. Selected interventions included a 2-week block release in which any unscheduled audiogram slots were open for general use for any patient needing an audiogram, audiology template revision with better alignment with physicians who frequently required audiogram schedules (otology, pediatrics), and reallocation of block time (Table 1). Changes were implemented over a 3-month period. Schedule utilization, lead time for new patient diagnostic audiogram, and RVUs were measured for 5 months postintervention (March 2014 to July 2014) and compared with 5 months preintervention (July 2013 to November 2013).

Statistical analysis was performed with $P$ values $<.05$ considered significant throughout the analysis. The Pearson $\chi^2$ test was used to analyze pre- and postintervention block utilization rates. An unpaired-sample $t$ test was used to determine significance of the change in average monthly RVUs from pre- to postintervention. In this prospective historically controlled study, the preintervention clinic serves as the control. This study was given an exemption from the Johns Hopkins Institutional Review Board.

**Results**

Analysis of the appointment scheduling process yielded the value stream map in Figure 1. Value stream mapping identified the presence or absence of open audiology appointments as a fork in the process stream. In the absence of available appointments, the scheduling process stream followed an inefficient path. Identified non-value-added steps in the absence of available appointments included difficulty finding appropriate audiology openings, forcing schedulers to contact audiology coordinators to locate open appointment slots, waiting for responses, and relaying appointment options back to the patient. Interventions were targeted at increasing the number of available appointments and eliminating non-value-added steps (Table 1).

Overall, 2995 preintervention and 3714 postintervention booked appointments were analyzed. Analysis of physician and audiology appointment times demonstrated poor alignment. Physician vacations were not reflected in audiology appointment templates; no preclinic audiology appointments were available for early-morning physician appointments; and daily availability of audiology visits compared with
physician visits was mismatched. These issues were resolved through the 2-week block release, starting and ending audiology appointment blocks 30 minutes earlier than physician blocks, and alignment of audiology appointment availability with physician clinic days. Executive health blocks had low utilization rates and were reduced by 23%, and joint-with-provider block time was doubled.

Overall block utilization increased from 77% to 90% after intervention ($P < .0001$). Utilization of joint-with-provider visits increased from 39% to 67% ($P < .0001$). Booked appointments increased from 2995 to 3714, with joint-with-provider booked appointments increasing from 317 to 1193. Appointment lead time averaged 24 days postintervention, compared with 29 days preintervention ($P = .06$).

Average monthly RVUs measured 13,321 preintervention and 14,778 postintervention ($P = .09$).

Discussion

Lean Sigma includes several tools, such as value stream mapping, to identify wasteful steps in a process for elimination. In this case, value stream mapping identified the lack of available audiology appointments as a fork in the scheduling process. The process followed in the absence of available appointments was inefficient, leading to frustration and delays in scheduling appointments. Lean Sigma analysis demonstrated multiple inefficiencies in the scheduling infrastructure. After block time was reorganized to more closely align with need and a 2-week block release was instituted, block utilization significantly increased from 77% to 90% ($P < .0001$). Appointment lead time averaged 24 days postintervention, compared with 29 days preintervention ($P = .06$), but this change did not reach statistical significance. Similarly, there was no statistically significant change in monthly RVUs, which averaged 13,321 preintervention and 14,778 postintervention. The failure to achieve statistical significance is unsurprising, as this study was not adequately powered to detect this difference. A power calculation indicated that 23 months pre- and postintervention would be necessary to achieve 80% power to detect a statistically significant increase in RVUs. While there were no statistically significant RVU gains, there were several noted improvements in efficiency (Table 2).

The techniques used in this study are inexpensive to implement but significantly improved clinic efficiency. Involving all stakeholders in value stream mapping is essential, not only because it allows a multidimensional analysis of clinic practices, but also because it produces personal investment in changing entrenched practices. Continued improvements in efficiency will require ongoing surveillance and modification of block scheduling. This process will include biannual review and adjustment of audiology and physician templates for alignment, as well as biannual review and adjustment of utilization of audiology blocks.

Although Lean Sigma methodology was applied in a tertiary care center in this study, the methods are readily generalizable to any practice setting. While the DMAIC and value stream mapping tools were applied in this project, there is a menagerie of tools that can be used as a part of Lean Sigma to address many types of inefficiencies. Through the stepwise approach of Lean Sigma, practices of any size can reduce wasteful steps and achieve higher patient volumes, with subsequent increase in revenue. There are a variety of books and courses available to guide practitioners interested in applying Lean Sigma to their own practices.

Use of Lean Sigma is gaining popularity in health care settings and has been successfully applied in otolaryngology clinics. A 2013 study from our institution successfully used Lean Sigma techniques to decrease patient wait time, increase on-time appointment start time, and decrease unnecessary motion. Wasteful steps were identified with value stream mapping in addition to time stamping and motion tracking. Interventions included prearrival telephone and letter reminders for patients to bring needed documentation, improved signage, realignment of registration staff schedules, change in the add-on patient policy, and decentralization of vital signs. Findings included a decrease in patient wait time by 12% ($P < .05$), improved on-time clinic visit starts by 34% ($P < .01$), and a reduction of motion by 34% in the outpatient otolaryngology clinic.

<table>
<thead>
<tr>
<th>Inefficiency</th>
<th>Intervention</th>
</tr>
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<tbody>
<tr>
<td>Appointment scheduling process too complex</td>
<td>Value stream mapping performed to streamline scheduling process</td>
</tr>
<tr>
<td>Underutilized audiology block time</td>
<td>Underutilized blocks decreased: executive health decreased 50%; joint-with-provider block time doubled</td>
</tr>
<tr>
<td>Unused audiology appointment slots</td>
<td>Two-week block release of unscheduled slots</td>
</tr>
<tr>
<td>Physician vacations not reflected in audiology appointment schedules</td>
<td>Two-week block release of unscheduled slots</td>
</tr>
<tr>
<td>Poor alignment of physician and audiology appointment schedules</td>
<td>Audiology schedule template realigned to mirror physician schedules</td>
</tr>
<tr>
<td>No audiogram appointments available for physician early-morning appointments</td>
<td>Start and end audiology schedule template 30 min earlier</td>
</tr>
</tbody>
</table>

Table 1. Interventions Used to Address Identified Non-value-added Steps.
Figures 1. Value stream map of the (a) pre- and (b) postintervention appointment scheduling process.

Table 2. Efficiency Improvement Noted after Lean Sigma Implementation.

<table>
<thead>
<tr>
<th>Efficiency Improvement</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Increased ease and decreased complexity of appointment scheduling</td>
<td>Decreased time and effort required to schedule appointments</td>
</tr>
<tr>
<td>Increased ease of obtaining audiogram at time of physician visit</td>
<td>Reduction in email burden for audiologists and audiology coordinators</td>
</tr>
<tr>
<td>Increased block utilization</td>
<td>Increased time available for more productive tasks</td>
</tr>
<tr>
<td></td>
<td>Reduction in nonproductive clinic time</td>
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<tr>
<td></td>
<td>Increased patients seen per clinic hour</td>
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<tr>
<td></td>
<td>Increases in patient satisfaction through reduced need for dual appointment</td>
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<tr>
<td></td>
<td>Reduction in loss of patients due to inability to schedule timely audiogram</td>
</tr>
<tr>
<td></td>
<td>Reduction in delays of care due to inability to schedule timely audiogram</td>
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Lean Sigma has been used to reduce lead time. A study published in 2014 successfully applied Lean Sigma techniques to reduce lead time from clinician order to completion of ultrasound-guided fine-needle aspiration from a range of 0 to 286 days to a range of 0 to 48 days.9 Lean Sigma techniques included value stream mapping, and intervention included implementing in-office ultrasound-guided fine-needle aspiration.

A 2009 study from Germany used Lean Sigma techniques to successfully reduce waiting times and increase patient satisfaction.10 Interventions included adjusting appointment duration by chief complaint, centralizing telephone appointment scheduling, and improving access of medical staff for patient questions over the telephone. Postintervention, waiting times were reduced, and patient satisfaction surveys demonstrated marked improvement in satisfaction with the scheduling process as well as physician availability by phone.

Several studies have commented on the limitations of Lean Sigma in health care.1,11,12 Criticisms focus on lack of outcome measures in the majority of Lean Sigma publications in the literature and paucity of statistical analysis, in addition to lack of standardization of the techniques used. This limitation is readily overcome by including outcome measures and statistical analysis. Limitations of this study include potential seasonal variation in audiometry appointments. Preintervention data were collected July 2013 to November 2013, and postintervention data were collected March 2014 to July 2014. The time frames of the study were constrained by the maternity leaves of 2 audiologists and availability of data prior to July 2013 due to change in electronic medical scheduling system. The seasonal variation is likely minimized, as each period includes some of the slower, summer months as well as busier fall/spring months.

This study adds to a small but growing number of studies demonstrating that clinical operations can be streamlined through the application of Lean Sigma. In the era of ever-decreasing reimbursements, maximization of efficiency will become paramount.

Conclusion

Value stream mapping was successfully used to reduce convoluted scheduling practices. Lean Sigma is a valuable tool to improve clinic efficiency and reduce waste.

Author Contributions

Matthew G. Huddle, analysis/interpretation of data, drafting of manuscript, final approval of version to be published, agreement to be accountable for all aspects of work; Amy Tirabassi, data acquisition, data analysis, critical revision, final approval, accountability agreement; Laurie Turner, conception of project, critical revision, final approval, accountability agreement; Emily Lee, conception of project, critical revision, final approval, accountability agreement; Kathryn Ries, conception of project, critical revision, final approval, accountability agreement; Sandra Y. Lin, conception of project, data analysis, critical revision, final approval, accountability agreement.

Disclosures

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