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Recovering from COVID – Improving operating room capacity



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Summary

Introduction

COVID-19 pandemic required that health systems made great efforts to mitigate the impact of high demands of patients requiring treatment. Triaging surgical cases reduced operating room capacity. Immunizations, massive testing, and personal protective equipment enabled re-activation of operating rooms. Delayed and newly added cases has placed stress on the system. We hypothesize that standardization in practice for tasks performed between anesthesia ready and surgery start time, also known as “prepping time”, can reduce operative time, improve efficiency and increase capacity. The aim of our project was to create and implement a best practice standardized prepping protocol, to explore its impact on operating room capacity.

Methods

Once local policies allowed re-opening of the operating rooms, our multidisciplinary group developed a working plan following Adaptive Clinical Management (ACM) principles to optimize surgical prepping time. Using electronic medical record (EMR) data, surgeons with the lowest surgical prepping times were identified (positive deviants). Their surgical prepping time workflows were reviewed. A clinical standard work (CSW) protocol was created by the team leader. New CSW protocol was defined and implemented by the leader and then by the rest of the surgeons. Baseline data was automatically extracted from EMR and analyzed by statistical process control (SPC) charts using AdaptX. Balancing

measures included “last case end time” and rates of surgical site infections.

Results

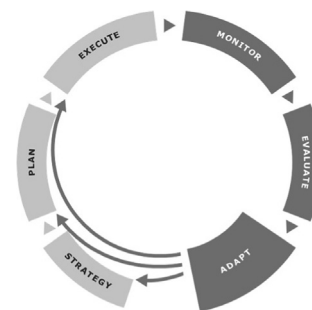
A total of 2506 patients were included for analysis with 1333 prior to intervention and 1173 after. Team leader implemented the new CSW prepping protocol showing a special cause variation with an average time improvement from 14.6 min to 11.6 min and for all surgeons from 13.8 to 12.0 min. Total cases per month increased from 70 to 90 cases per month. Baseline ‘Last Case End Time’ was 15.7 min later than the scheduled. New CSW improve end time with an average of 20.8 min before the schedule. Baseline surgical site infection was 0.1% for the study population. No difference was seen after implementation.

Discussion

Variations in performance can be quantified using funnel plots showing individual practices allowing best practice to be identified, tested and scaled. Implementation of our surgical prepping time protocol showed a sustainable increase in efficiency without affecting quality, safety or workload. This additional increase is estimated to represent approximately \$2–2.5M additional revenue per year.

Conclusion

Adaptive clinical management is a practical solution to increase OR capacity by improving efficiency to reduce extra burden presented during COVID19 pandemic.



Summary Figure Adaptive clinical management case study: increase capacity in urology or by optimizing ‘surgical prepping time’.

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Introduction

After the COVID-19 was declared a pandemic, health systems worldwide made great efforts to mitigate the impact of high demands of patients requiring admissions. One of these measures included an aggressive triage of surgical cases with many operating rooms only being used for life threatening conditions. In pediatric urology, these recommendations were also implemented with many cases being postponed for months. The mid and long-term impact on most pediatric patients who had their surgeries postponed is unknown. The COVID 19 economic impact in 2021 has been estimated to be an overall loss of between \$53B to \$122B in revenue [1]. Health care systems will need to adapt and find efficient ways to recover from the mid and long-term economic effects posed by the pandemic. Solutions to increase operating room capacity and reduce long waiting times needs to be a priority for the coming months and years.

Availability of immunizations against COVID-19 for healthcare providers and patients, massive testing, and adequate personal protective equipment availability enabled reactivation of operating rooms. Nonetheless, delayed and newly added cases has placed a lot of stress on the system. As a result, implementing and improving operating room capacity is imperative. Over the years many strategies have been suggested for optimizing OR performance (e.g., reorganizing scheduling, rethinking block utilization, changing leadership structures and instituting daily team huddles). While all these strategies do have merit, they do not in themselves produce the kind of efficiency gains that are urgently needed to increase capacity. Following similar prior experiences in our group, we structure this project with an Adaptive Clinical Management (ACM) structure (Fig. 1). [2]. ACM is an iterative process of robust decision making, based on data supplied by active monitoring of electronic medical record (EMR). ACM is a method to not just change but *also* learn about how a system actually works. A critical step is the ability to evaluate results and adjust actions (adapt) on the basis of what has been learned. Use of a statistical approach to interpret the impact of newly implemented changes and keep track over time can be evaluated graphically using statistical process control (SPC) charts. Barriers of implementation of ACM in healthcare include not collecting data, not analyzing data, not giving access to the data to the decision makers working in the front lines, and/or analyzing data but failing to use the insights to make decisions. The aim of this project was to increase the capacity of the OR by focusing on reducing the surgical prepping time (defined as time from anesthesia ready to incision or start time). Success would mean additional time available so the team was able to care for more patients without extending their working day. We hypothesize that standardization in practice for tasks performed between anesthesia ready and surgery start time, also known as “prepping time”, can reduce overall operative time, improve efficiency and increase capacity. The aim of our project was to create a best practice standardized prepping time protocol, implement it, evaluate its impact on overall operative times and then use any time saved to perform additional surgeries.

Methods

Once local policies allowed the re-opening of the operating rooms, our multidisciplinary group involving anesthesia, nursing, operating room administration and pediatric urology stakeholders developed a working plan following ACM principles to optimize surgical prepping time. Surgical prepping time was defined as the time between anesthesia ready and surgical incision. This was initially explored and implemented at our high volume outpatient surgery center.

Using routinely captured electronic medical record (EMR) data from the operating room. Surgeons with the lowest surgical prepping times were identified (positive deviants). Their surgical prepping time workflows were reviewed. Common factors in their practice were identified, including specific tasks performed during the surgical prepping time, solutions used for prepping, sequencing of task execution, and the role allocation of other team members. A clinical standard work (CSW) protocol was defined by the team leader based on learnings from interviewing these surgeons with the best performance. Once a CSW protocol was defined, the team leader led by example. He implemented for his own practice, measured surgical prepping time for his own cases, and openly shared his own performance data with the urology team (an additional seven surgeons).

Context

The Surgery Center (BSC) is a satellite campus separate from our pediatric main campus hospital. Our EMR includes perioperative data since 2014. There are 4 operating rooms with Post-Anesthesia Care Unit (PACU) capacity for 14 patients. At BSC, elective ambulatory surgeries for Urology, Otolaryngology, Orthopedics, General Surgery, Plastic Surgery Dental and Ophthalmology are performed on relatively healthy patients (96% of patients have American Society of Anesthesiologist (ASA) scores of 1 or 2, with age ranges between 6 months and 18 years). All other complex patients or surgeries are sent to the main campus hospital. BSC operates as a Learning Health System, defined by the Institute of Medicine as “a system in which science, informatics, incentives, and culture are aligned for continuous improvement and innovation, with best practices seamlessly embedded in the delivery process and new knowledge captured as an integral by-product of the delivery experience [3].” Anesthesiologists, surgeons, nurses, and technologists huddle each morning to review any obstacles to patient safety or efficiency and propose solutions. BSC performs roughly 4000 procedures annually with approximately 17% (700) being urologic surgeries. This project was designed and executed exclusively for patients with urological (genital and inguino-scrotal) conditions (circumcision, phalloplasty, hypospadias repair, inguinal and or scrotal orchiopexy, hydrocelectomy, inguinal hernia repair and other minor penile procedures). For cases that an exam under anesthesia was required to decide final surgical plan, surgeons performed this exam in the induction room during induction at the moment intra venous access and before

intubation. This allowed the anesthesia team to decide between endotracheal intubation and laryngeal mask (LMA) and the type of regional anesthesia. This exam under anesthesia was not included in our prepping time protocol. Following prior experiences in similar projects in our group, this new protocol was developed and implemented with input from all operating room stakeholders (surgeons, anesthesiologists, nursing staff and surgical technologists) [4].

Interventions

Clinical standard work – new surgical prepping protocol

A full 5-min scrub is performed by the surgeon and scrub tech before start of day [5]. This allows for shorter scrub times using an alcohol-based surgical hand disinfecting agent for all subsequent cases throughout the day. After induction of anesthesia and placement of regional blocks in a connected but separated induction room, an anesthetized patient enters the operating suite on a stretcher and the following tasks are completed by the team (anesthesiologist/anesthesia RN, circulating nurse, surgeon scrub-tech and when available trainee):

1. Patient is transferred to the OR table from anesthesia induction room.
2. Patient is positioned, secured and has a grounding pad applied.
3. Pressure point areas are protected with soft padding.
4. Surgical field is prepared.
5. Team performs a standardized safety time out.
6. Patient is draped, surgical instruments are connected and configured for operation.
7. Surgery Starts.

The emphasis is on coordinated team work with parallel work happening whenever possible. The surgeon and the circulator nurse work *together* to position, pad, ground and securing the patient to the operating table. Parallel work occurs by specific task allocation - one person focuses on upper body and the other on lower body. The surgeon then preps with betadine while the trainee or surgical assistant scrubs. The trainee or surgical assistant then drapes the patient while the attending scrubs. Simultaneously the circulating nurse connects surgical instruments. The aim is to have the attending surgeon scrubbed, gowned and ready to operate as the patient's surgical field is draped. Thereby minimizing non-value added time in the operating room.

Study of the intervention

Baseline data were automatically extracted from the EMR and analyzed by statistical process control (SPC) charts using AdaptX (Seattle, WA) (Fig. 2A). SPC were used to identify statistically significant differences between providers and then monitor changes. Variation between surgeon performance was analyzed using funnel plots, and best performing (positive deviant) surgeons were identified and interviewed [6] (Fig. 2B). A CSW protocol (Table 1) derived from those interviews was implemented, at first by a clinical champion and then by the wider group. Data for clinical

performance was evaluated and fed back on a daily basis to surgeons so they could continue to learn and iteratively adapt and fine tune their workflows to achieve higher levels of efficiency.

Measures and analysis

1. Surgery Prepping Time

The patient's surgical journey was mapped out into distinct process from anesthesia start in the induction room to patient exiting the operating room using routinely collected time stamps in the EMR. Surgery Prepping Time was defined as the time interval between anesthesia readiness (successful completion of all anesthesia tasks - induction, intravenous access, intubation and, when required, a regional anesthesia block) and start of the surgical procedure (procedure start time) for ambulatory pediatric urology cases.

2. Last Case End Time Delta and Surgical Site Infections

To determine whether the new prepping protocol could be affecting other parts or components of the system, we decided to focus on these two balancing measures to assess: 1. Staff work load and 2. The effect on postoperative outcomes.

With the limitations imposed during the pandemic, the need to increase operating room capacity was a priority. We wanted to explore ways to increase capacity without adding extra time to our staff. For the last case end time delta metric, the time difference was calculated between the last patient leaving the OR and the scheduled end of that last case. This delta was used to evaluate the potential impact on team work-load. We focused on how much time could be reduced or increased on the overall team shift working hours. We did not explore other balancing measures that would look at team members workload and satisfaction as we felt that the new protocol was not going to add extra work or

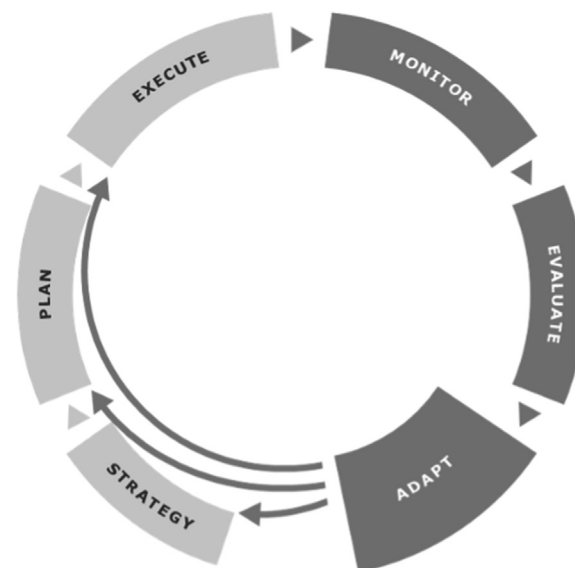


Fig. 1. Adaptive clinical management case study: Increase capacity in urology OR by optimizing 'surgical prepping time'.

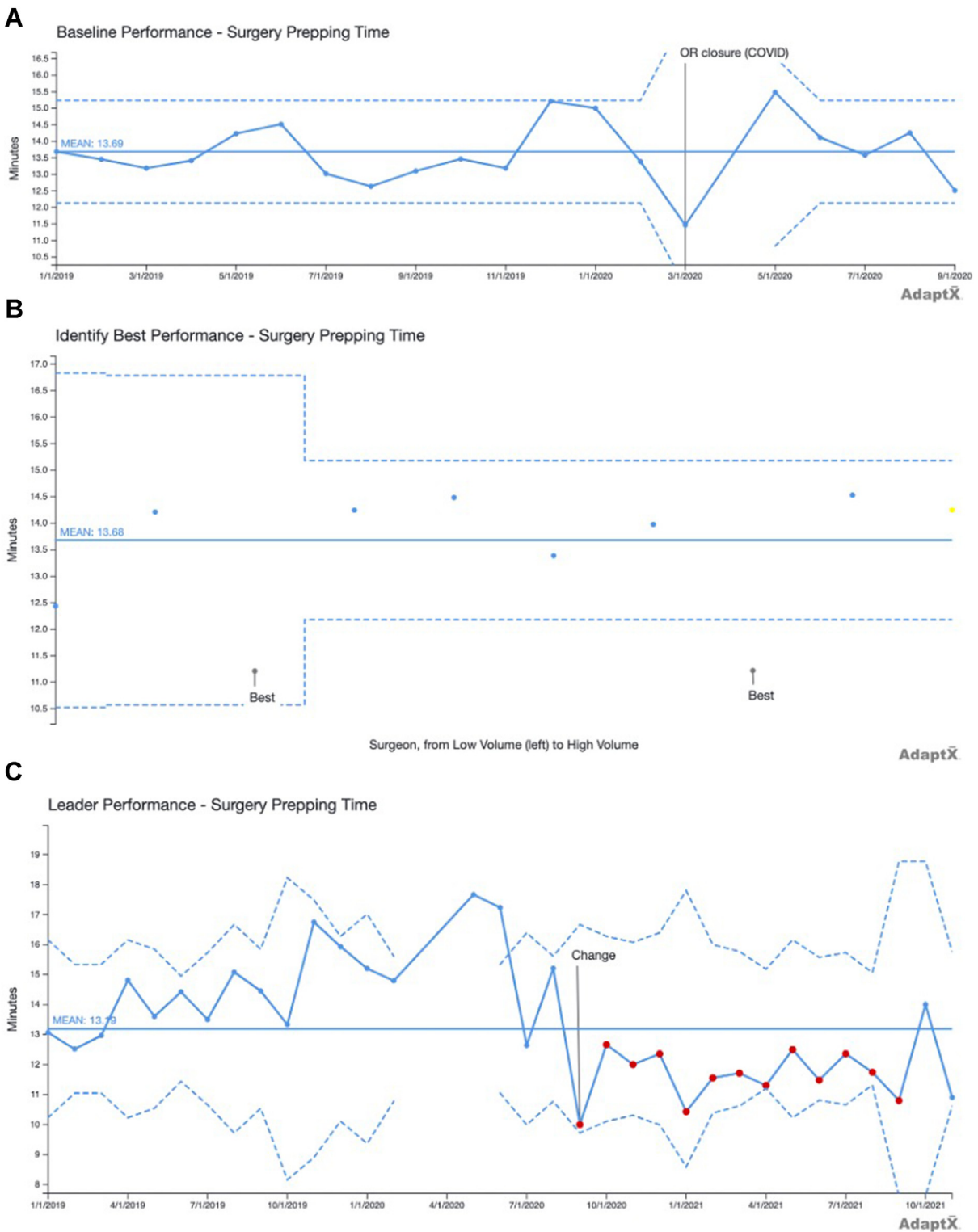


Fig. 2 A: X-bar chart - baseline performance: Surgical prepping time. B: Funnel plot of baseline performance – stratified by individual surgeons. C: X-bar chart - team Leader’s personal surgical prepping time: Demonstrates improvement after new CSW implemented (9/1/2020).

additional tasks to their normal working routine. Changes implemented with the new protocol are described above.

Since a major change for the new standard prepping protocol included a change in prepping solutions, overall

prepping times, hand sanitation, we wanted to keep surgical site infection as a principle balancing measure to monitor in order to prevent any potential risk to the patient and surgical outcomes at the expense of this new change.

Table 1 Summary of implemented tasks for the new CSW.

| Task | Change |
|--------------------|--|
| Skin prepping | All cases were prepped with betadine instead of Chloro-prep. |
| Surgeon's presence | Surgeons were asked to be present in the room before the start of the "prepping time" and assist with all steps of the "prepping time". |
| Handwash | Do the 5-min handwash before the first case of the day and then use alcohol-based solution for handwashing for remaining cases of the day. |
| Designate tasks | We changed from one individual preparing the patient to a team working simultaneously. All team-members would participate in patient positioning. Each team-member had a defined role during the "prepping time". Surgeon would do skin prepping while circulating nurse would pad, secure, and ground the patient. |

Our hospital systematically monitors allurgical site infection metric. These data are also captured through AdaptX. We evaluated reported infections prior and after implementation of the protocol during the study period. This information was crosschecked with the manual input report provided via the electronic medical record.

Ethical considerations

Given the model and nature of this project, we waived institutional review board approval. Since the proposed new protocol did not vary from our standard of care, we did not consider patients were at any risk with this new change in protocol. Analysis did not require patient contact and data was analyzed anonymously and blinded with the software.

Results

A total of 2506 patients were included for analysis with 1333 prior to intervention and 1173 after (Table 2).

Baseline performance for surgery prepping time from 1/2019 to 8/2020 included a total of 1333 patients (Fig. 2A). System performance is 13.7 min and stable (indicated by lack of special cause variation). No data was registered for the month of 4/2020 due to OR closures related to COVID-19.

A funnel plot analysis (Fig. 2B) was used to quantify the variation between surgeons and identify those with the highest performance. Two surgeons (positive deviants) were identified with the best surgical prepping times (11.2 min). One surgeon was identified as special cause variation, falling below the 3-sigma lower control limit. The other surgeon, had an identical performance (11.2 min), but had performed fewer surgeries in that time frame, and therefore did not fall outside the lower control limit.

Team leader (represented in yellow in Fig. 2B) implemented the new CSW prepping protocol in September 2020. Fig. 2C shows his performance improved after

Table 2 Patient characteristics before and after intervention.

| Characteristics | Before (N = 130) | After (N = 1173) |
|----------------------------|--------------------|--------------------|
| Demographics | | |
| Patient Race and Ethnicity | 700 (52.51%) | 559 (47.66%) |
| Non-Hispanic White | 147 (11.03%) | 133 (11.34%) |
| Hispanic | 134 (10.05%) | 132 (11.25%) |
| Asian | 100 (7.5%) | 113 (9.63%) |
| 2 or more races | 88 (6.6%) | 92 (7.84%) |
| Unknown/Refused/Other | 164 (12.3%) | 144 (12.28%) |
| Patient preferred language | | |
| English | 1227 (92.05%) | 1064 (90.71%) |
| Other than English | 106 (7.95%) | 109 (9.29%) |
| Patient Weight | 21.77 (5.94–112.9) | 20.36 (5.76–105.6) |
| ASA Score | | |
| 1 | 872 (65.42%) | 810 (69.05%) |
| 2 | 440 (33.01%) | 356 (30.35%) |
| 3 | 19 (1.43%) | 6 (0.51%) |
| N/A | 2 (0.16%) | 1 (0.09%) |
| Age Groups | | |
| Infant (0 years) | 337 (25.28%) | 442 (37.68%) |
| Toddler (1–3 years) | 440 (33.01%) | 326 (27.79%) |
| Childhood (6–12 years) | 304 (22.81%) | 244 (20.8%) |
| Preschool (4–5 years) | 142 (10.65%) | 86 (7.33%) |
| Adolescence (13–18 years) | 108 (8.1%) | 70 (5.97%) |
| Other | 2 (0.15%) | 5 (0.43%) |

implementation, special cause variation is highlighted in red. His average time improves from 14.6 min to 11.6 min.

All the surgeons in the group adopted the new CSW protocol and average prepping time improved from 13.8 to 12.0 min (Fig. 3). There was a special cause variation between the 'before' and 'after' cohorts with 8 points below the centerline.

As a result of this improved efficiency patient flow in this facility was increased, which reflected in an increase in monthly case volume from 70 urology cases a month to an 90 cases a month (Fig. 4).

Over the last 4 months of the study period, a record total cases were performed. Including an all time high in one month (7/2021) when 107 surgeries were performed. This additional volume is estimated to represent approximately \$2–2.5M additional revenue per year.

'Last Case End Time' during measurement of baseline performance, the last patient out of OR time was 15.7 min later than the scheduled end time. After new prepping protocol was implemented, the last patient was leaving the OR on average 20.8 min before the scheduled case end time (Fig. 5) this suggests there is still unrealized capacity in the system. Prior to implementing the protocol, the surgical site infection rate was 0.1% for the study population. There was no difference reported after implementation of the study period.

Discussion

Adaptive clinical management is a practical solution to increase OR capacity by improving efficiency. All OR

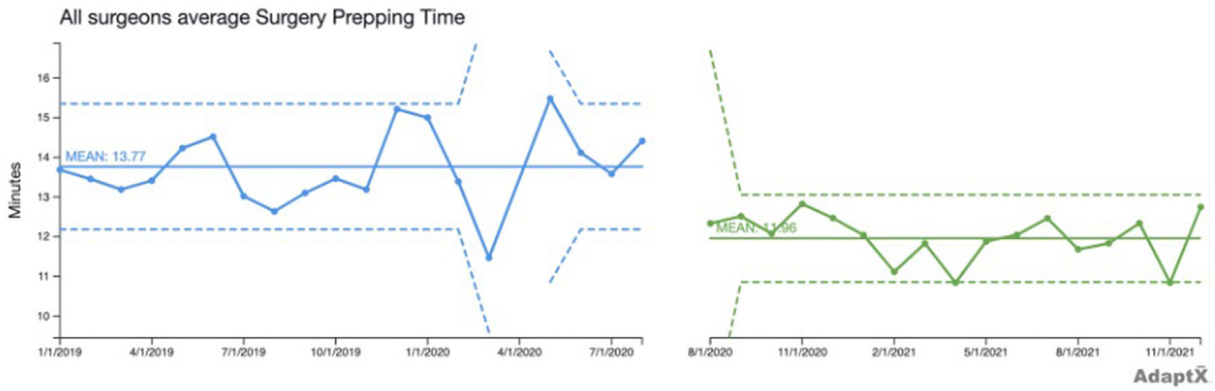


Fig. 3 All Surgeons’ Performance for surgery prepping time before (blue) and after (green) implementation of the new standard protocol. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

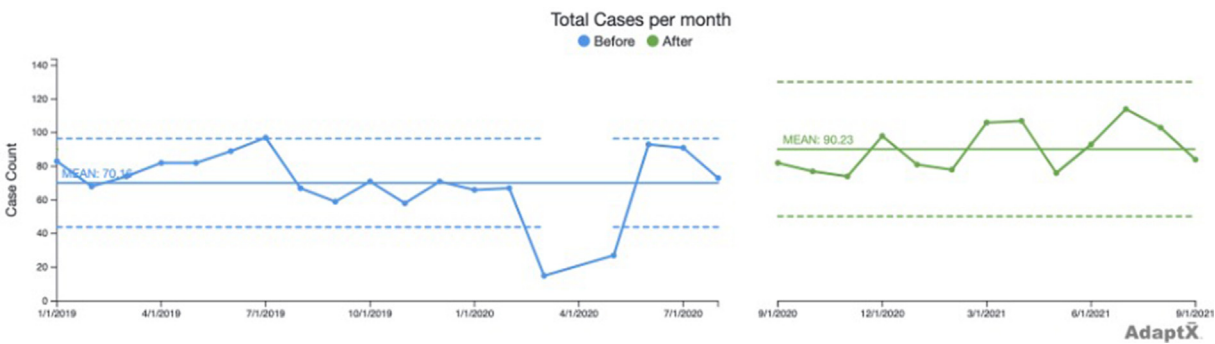


Fig. 4 Total cases performed per month before and after implementation of the new Prepping protocol.

processes can be *measured* using routinely captured data in the EMR and continuously *monitored* using SPC charts. Our results demonstrate how variations in performance can be quantified using funnel plots showing individual practices allowing best practice to be identified, tested and scaled. During and following implementation of new clinical standard work, the effect on individual and team performance can be monitored, allowing the team to learn more.

Small tests of change are possible by implementation, initially by some individuals in the group, then rapidly scaled to rest of the team. Adaptive clinical management is a paradigm shift in how rapidly healthcare thinks of impro-

vement can happen. It moves us beyond time consuming, slow moving Plan-Do-Study–Act cycles which take years to execute and are rarely completed to a far more agile system where iterative steps can be taken in days or weeks. This requires leadership to implement and teamwork to ‘buy-in’ and sustain gains.

Our urology team demonstrates it is feasible to improve system performance by changing and adapting our practices. Our analyses using SPC charts have shown we are able to sustain those gains and increase OR efficiency and capacity without compromising safety. Following this same approach, changes in anesthesia induction times, prepping

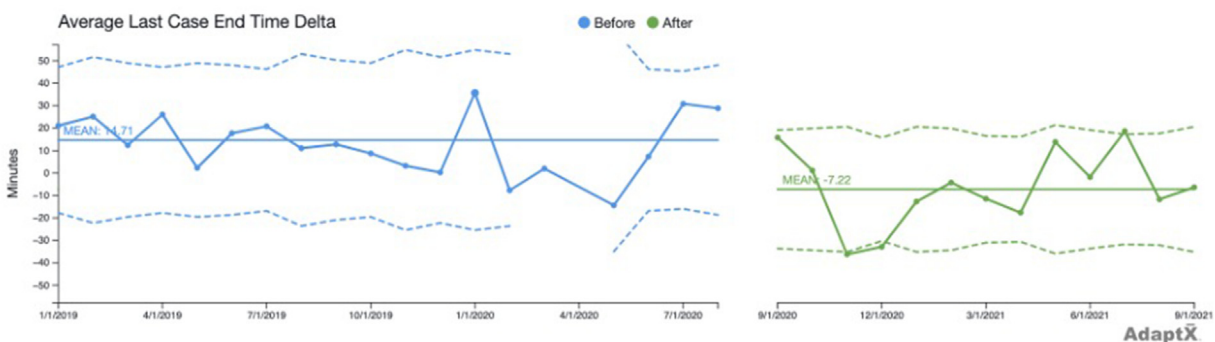


Fig. 5 ‘Last Case End Time’ – ‘Scheduled Last Case End Time’ - Before and After Implementation of new CSW prepping protocol.

times, emergence times, OR turnover were also studied, allowing for other teams to implement changes in their practice with similar positive results. These small gains made at a system level quickly add up to additional freed up OR minutes which translates into extra capacity.

The mid and long-term effects of operating room closures and other initial restrictions intended to mitigate the effect COVID-19 pandemic are yet to be seen [7,8]. The U.S. healthcare system needs an effective methodology to improve efficiency to meet demand. Since initial recommendation to triage surgical cases gave priority to oncological and emergent cases, non-urgent procedures were mostly severely affected. Some centers have demonstrated increases in waiting times up to 25% [9]. Without a clear end to the pandemic in the near future, health systems will continue to be tested and immediate effective measures are needed to increase capacity [7].

Another consequence of the COVID-19 pandemic has been increased burnout of healthcare workers which has led many to retire from the workforce resulting in staff shortages [10]. Models that intend to improve capacity cannot rely on changes that depend on increasing manpower or workload. Our results demonstrate that capacity can be improved without increasing staffing or workload, but instead, by re-thinking and re-designing workflows of established routine tasks. In fact, we demonstrate that implementation of the new CSW protocol allowed the team to finish the operating room earlier at the end of the day.

Implementation of our surgical prepping time protocol showed a sustainable increase in efficiency without affecting quality or safety. We believe that this identical protocol may not demonstrate similar results if applied to more complex surgeries like robot assisted, laparoscopic, microscopic or endoscopic procedures where surgical prepping times also include setting up instruments and docking robotic arms. We do believe though a similar approach to measuring variation, identifying positive deviants, scaling their work patterns could lead to similar gains in efficiency, effectiveness and capacity.

Despite focusing on only on the prepping time, we did not report the behaviour of other components of the overall operative time that could have affected efficiency. Nonetheless, our AdaptX software does keep track of all these different components and we did not see any associated changes that demonstrated statistically significant trends that could explain our results.

We acknowledge that our study model only applies in very specific settings and it might be required to explore if this model would also be applicable in more complex operating room scenarios where patient surgical journey is more unpredictable. Similar if the surgical team constantly rotates and it becomes more difficult to engage them in a model like this.

Although we did not explore this during the study, it would be of interest to evaluate how stakeholders (surgeons,

anesthesiologists, scrub techs, circulating nurses) feel about these new changes.

Conclusions

Adaptive clinical management enabled our team to use real-world EMR data to identify best practices in our group, establish clinical standard work, and implement those changes supported by real-time monitoring of that data. This method for developing a standardized surgical prepping protocol in our high-volume outpatient surgery center demonstrates a practical and feasible approach to increasing surgical capacity in our stressed systems.

Conflicts of interest

One of the authors, Daniel Low is Co-founder and Chief Medical Officer of AdaptX. All other authors on this manuscript do not have any conflicts of interest to declare.

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