Remote video auditing in healthcare: A powerful tool for patient and clinician safety culture and operational efficiencies

Received (in revised form): 9th November, 2021

Michael H. Goldberg

Former Executive Director, Long Island Jewish Medical Center, USA

Michael Goldberg, MBA, MHCDS, FACHE, is the former Executive Director of Long Island Jewish Medical Center (LIJMC), where from May 2015 through the end of 2021 he was responsible for the day-to-day operations of the hospital's 583 beds, 6,500 employees and 4,000 physicians. Working with the leadership team at LIJ, Mr Goldberg drove clinical and operational initiatives to ensure appropriate, safe, efficient and innovative care to patients. At the heart of the original epicentre of COVID-19 in the United States, Northwell Health treated over 100,000 people, with LIJ located at the centre of the pandemic in Queens, New York. LIJ was also the site of the first non-trial vaccine administered in the United States. Mr Goldberg led the hospital through a critical time, ensuring that high-level clinical care and safety was maintained. Before joining LIJ, Mr Goldberg worked in Northwell's financial planning department, where he was responsible for capital planning, business plans and financial analytics. He is a fellow of the American College of Healthcare Executives and an adjunct professor at Hofstra University's Department of Health Professions. Mr Goldberg received his master of health-care delivery science from Dartmouth College, and holds a bachelor's in business administration from the University of Rhode Island and an MBA in finance from Hofstra's Frank G. Zarb School of Business.

Hofstra University, Long Island Jewish Medical Center (LIJMC), Northwell Health,
270-05 76th Avenue, New Hyde Park, NY 11040, USA
Tel: +1 718 470 7000; E-mail: michaelgoldbergdirect@gmail.com

Sheldon B. Newman

Area Vice President, North American Partners in Anesthesia, USA

Sheldon B. Newman, MD, is the Chairman of Anesthesia at LIJMC and North Shore University Hospital, as well as the Peter F.R. Walker, MD, Chair in Anesthesiology at the Zucker School of Medicine at Hofstra University/Northwell Health. In addition, he is the Area Vice President for North American Partners in Anesthesia–Northwell hospitals, responsible for the clinical and operational management of eight hospitals. Included in these locations are tertiary facilities, community hospitals and ambulatory surgery centres. Dr Newman is a recognised innovator in the areas of patient safety and operating room efficiency. Passionate about improving patient safety protocols and utilising technology to drive measurable results in efficiency, throughput and quality, his vision has been translated into several successful initiatives. Among his clinical and operational innovations, Dr Newman had an operating room (OR) code panel installed in the hospitals' anaesthesia office, so that when a code blue alarm is called for emergent assistance in the OR, the anaesthesia clinicians are instantly notified, saving response time, and therefore lives. In an example of using simple technology to enhance efficiency, Dr Newman, seeking to improve first-case start times, needed an objective measure to document surgeons' and anaesthesiolgists' arrival times. Installing identification card readers, such as those used to open hospital doors, in the holding area proved to be an effective solution. Dr Newman earned his medical degree, graduating cum laude, from the Technion School of Medicine, in Haifa, Israel. He practised cardiac anaesthesia for more than 25 years, and now spends the majority of his time in administrative and executive roles. His professional affiliations include membership in the American Society of Anesthesiologists and New York State Society of Anesthesiologists.

North American Partners in Anesthesia (NAPA), 68 S. Service Road, Suite 350, Melville, NY 11747, USA
Tel: +1 516 470 7390; E-mail: snewman@napaanesthesia.com

Abstract Medicine struggles to effect meaningful improvements in patient safety that do not come at the expense of efficiency. Rarer still are evidence-based tools that can provide sustained safer care while delivering operational efficiencies that produce better clinical and financial outcomes. This paper describes how Northwell Health, New York's largest health-care provider, has instituted innovative remote video auditing (RVA) technology in its operating rooms, intensive care units and hospital floors, and the results it has achieved in nearly a decade of progressive applications and expanding adoption across its 23 hospitals. The paper demonstrates that implementation of this technology, which is compliant with the Health Insurance Portability and Accountability Act of 1996 (HIPAA), and associated change management, has improved culture and productivity in the operating room and hospital-wide. Benefits achieved through the RVA-with-feedback methodology include increased capacity, improved first-case starts, higher compliance with hand hygiene and the surgical safety checklist, reduced surgical site infections, shorter room turnover and expedited patient flow. The associated increases in patient and surgeon satisfaction, and significant financial savings, have substantial implications for hospitals seeking new pathways to enhanced patient safety and profitability.

KEYWORDS: patient safety, remote video auditing, surgical safety checklist, hand hygiene, operational efficiencies, surgical site infection

INTRODUCTION

The surgical safety checklist (SSC) developed by a team led by Atul Gawande, MD, and adopted by the World Health Organization (WHO) in 2008, represented a revolution in the nascent patient safety movement. When the *New England Journal of Medicine* published its landmark 'Special Article' describing the case for the checklist in January 2009,[1] it showed that the use of an SSC can decrease perioperative morbidity and mortality by one-third and decrease perioperative surgical site infections (SSIs) by up to 50 per cent. As the patient safety field has matured, numerous studies have documented how simple interventions, such as appropriate hand hygiene, can reduce healthcare-associated infections (HAIs)[2] and thereby improve the patient experience.

Despite the evidence for protocols that promote patient safety, changing human behaviour is challenging. In 2013, the U.S. Agency for Healthcare Research and Quality summarised as follows:

> Although it is well-accepted that hand hygiene is a critical patient safety practice for reducing healthcare-associated infections, compliance with this practice is often low. . . . Reviews have found that the results of hand hygiene compliance interventions were mixed, with effectiveness waning over the long term.[3]

The economic impact of HAIs, including SSIs, on hospitals worldwide has also been well documented over the past two decades. The 2019 WHO report on 'Patient Safety and Risk Management Service Delivery and Safety'[4] advised as follows:

> Investment in improving patient safety can lead to significant financial savings and more importantly better patient outcomes. This is because the cost of prevention is typically much lower than the cost of treatment due to harm. As an example, in the United States alone, focused safety improvements led to an estimated US$28bn in savings in Medicare hospitals between 2010 and 2015.[5,6]

In the years following the checklist's introduction, various policies attempted to incentivise clinician compliance in the

operating room (OR), often to no avail. The National Quality Forum (NQF) identified the problem in its report 'Safe Practices for Better Health Care':

> In most settings today, the high-risk, error-prone nature of modern healthcare and the shared responsibility for risk reduction are not widely recognised. Free and open communication and non-punitive reporting of adverse events and patient safety concerns are not the norm, and organisational objectives and rewards are not clearly aligned with the goal of improving patient safety. To address these issues, there is a need to promote a culture of safety in all health care settings — a safety-conscious culture demonstrating the values, attitudes, competencies and behaviours that determine the commitment to health and safety management.[7]

NQF further stated that an essential ingredient of a sustainable safety-conscious culture is culture measurement, feedback and intervention, but 'measurement by itself is not enough. It must be coupled with feedback systems and performance improvement activities that can inspire the entire organization'.[8]

In this paper, we discuss one such system that has transformed hospital cultures with real-time feedback and non-punitive interventions that drive meaningful improvements in safety and efficiency, in and beyond the OR. Hospitals operated by Northwell Health, a 23-hospital health system serving the New York City metropolitan area, have used an innovative remote video auditing (RVA) technology since 2013 to achieve measurable results, reducing infections, increasing compliance, improving outcomes and speeding room turnover by as much as 20 per cent. Even at the epicentre and height of the COVID-19 pandemic in the United States, the positive outcomes that Northwell's hospitals achieved with RVA proved sustainable through unprecedented challenges in capacity and patient safety.

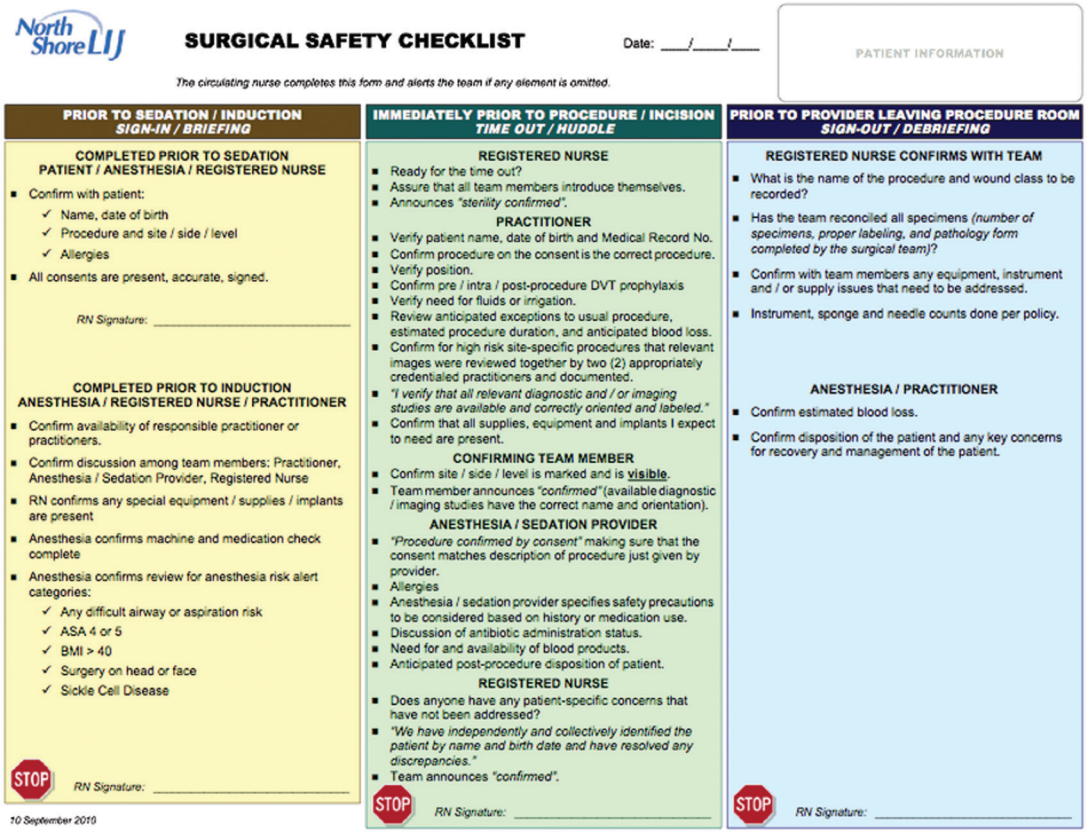
A landmark study published in the *British Medical Journal of Quality and Safety* in 2016 demonstrated the results that Northwell's Long Island Jewish Medical Center (LIJMC) had realised using RVA technology to improve patient care and throughput processes.[9,10] Inspired by the improvements in patient safety and the financial gains achieved as a result of implementing operational efficiencies, Northwell has continued to expand RVA applications across its hospital system. LIJMC also deployed RVA efficiencies to grow its capacity, enabling New York's busiest hospital to treat nearly 1,000,000 emergency department (ED) patients since 2007. RVA fosters a safety-focused culture of communication and collaboration, aligning goals among clinicians and health-care administrators with a significant positive impact on patients, productivity and profitability.

BOOSTING COMPLIANCE WITH THE SSC

RVA innovation was first introduced at LIJMC to produce better clinical outcomes in two areas that had a direct impact on patient safety. One was the SSC, introduced just over a decade ago, which has become a staple of inpatient and outpatient surgical rooms. Then and now, it is typically in the form of a placard, perhaps posted on a wall or clipboard hung in the OR. An anaesthesia clinician or nurse is most often charged with reviewing the checklist to ensure that each of the approximately 15–20 items are met.

As designed by Dr Gawande and WHO, the original checklist featured customisable guidelines built around three discrete items: the sign in, which occurs prior to the induction of anaesthesia; the time out, which occurs prior to skin incision and the sign out, which occurs prior to the completion of the procedure.

The checklist used by Northwell Health hospitals for many years was derived from the original WHO template and modified with the addition and deletion of specific



North Shore LIJ

SURGICAL SAFETY CHECKLIST Date: ___/___/___

PATIENT INFORMATION

The circulating nurse completes this form and alerts the team if any element is omitted.

PRIOR TO SEDATION / INDUCTION
SIGN-IN / BRIEFING

COMPLETED PRIOR TO SEDATION
PATIENT / ANESTHESIA / REGISTERED NURSE

- Confirm with patient:
  - ✓ Name, date of birth
  - ✓ Procedure and site / side / level
  - ✓ Allergies
- All consents are present, accurate, signed.

RN Signature: _____

COMPLETED PRIOR TO INDUCTION
ANESTHESIA / REGISTERED NURSE / PRACTITIONER

- Confirm availability of responsible practitioner or practitioners.
- Confirm discussion among team members: Practitioner, Anesthesia / Sedation Provider, Registered Nurse
- RN confirms any special equipment / supplies / implants are present
- Anesthesia confirms machine and medication check complete
- Anesthesia confirms review for anesthesia risk alert categories:
  - ✓ Any difficult airway or aspiration risk
  - ✓ ASA 4 or 5
  - ✓ BMI > 40
  - ✓ Surgery on head or face
  - ✓ Sickle Cell Disease

STOP *RN Signature:* _____

10 September 2010

IMMEDIATELY PRIOR TO PROCEDURE / INCISION
TIME OUT / HUDDLE

REGISTERED NURSE

- Ready for the time out?
- Assure that all team members introduce themselves.
- Announces *"sterility confirmed"*.

PRACTITIONER

- Verify patient name, date of birth and Medical Record No.
- Confirm procedure on the consent is the correct procedure.
- Verify position.
- Confirm pre / intra / post-procedure DVT prophylaxis
- Verify need for fluids or irrigation.
- Review anticipated exceptions to usual procedure, estimated procedure duration, and anticipated blood loss.
- Confirm for high risk site-specific procedures that relevant images were reviewed together by two (2) appropriately credentialed practitioners and documented.
- *"I verify that all relevant diagnostic and / or imaging studies are available and correctly oriented and labeled."*
- Confirm that all supplies, equipment and implants I expect to need are present.

CONFIRMING TEAM MEMBER

- Confirm site / side / level is marked and is **visible**.
- Team member announces *"confirmed"* (available diagnostic / imaging studies have the correct name and orientation).

ANESTHESIA / SEDATION PROVIDER

- *"Procedure confirmed by consent"* making sure that the consent matches description of procedure just given by provider.
- Allergies
- Anesthesia / sedation provider specifies safety precautions to be considered based on history or medication use.
- Discussion of antibiotic administration status.
- Need for and availability of blood products.
- Anticipated post-procedure disposition of patient.

REGISTERED NURSE

- Does anyone have any patient-specific concerns that have not been addressed?
- *"We have independently and collectively identified the patient by name and birth date and have resolved any discrepancies."*
- Team announces *"confirmed"*.

STOP *RN Signature:* _____

PRIOR TO PROVIDER LEAVING PROCEDURE ROOM
SIGN-OUT / DEBRIEFING

REGISTERED NURSE CONFIRMS WITH TEAM

- What is the name of the procedure and wound class to be recorded?
- Has the team reconciled all specimens *(number of specimens, proper labeling, and pathology form completed by the surgical team)*?
- Confirm with team members any equipment, instrument and / or supply issues that need to be addressed.
- Instrument, sponge and needle counts done per policy.

ANESTHESIA / PRACTITIONER

- Confirm estimated blood loss.
- Confirm disposition of the patient and any key concerns for recovery and management of the patient.

STOP *RN Signature:* _____

Figure 1: Surgical safety checklist used by Northwell Health, New York, USA.

items (Figure 1); however, over time, we found that there were two very significant drawbacks to this placard on the wall. One was that, in the OR, we were reviewing only those line items that pertained to the procedure in front of us, rather than verbally confirming every item on the checklist as Dr Gawande had intended. In other words, we quickly ran through a shorter, edited version. The second drawback was a lack of reliability: we had no way to know how often or how well we were completing the SSC, in every operating room, every day.

To address the first issue, we converted the checklist placard to a question and answer format. Answering every question individually, the anaesthesia provider would complete the sign in and the time out, and the circulating nurse would typically complete the sign out.

For the reliability component, we installed a rudimentary audit tool in which a nurse manager with a clipboard came into the OR on a random basis, observing 10 to 30 cases per week, as we performed the SSC.

A BETTER TOOL FOR COMPLIANCE IN EVERY CASE, EVERY DAY

The results we achieved with our audit process were the epitome of the Hawthorne effect: clinicians being observed by the nurse manager were always 100 per cent compliant. We must state at the outset that we believe that health-care practitioners come to their sites with a daily desire to do the right thing and take the best-possible care of our patients; however, without constructive feedback, how does anyone know how they are actually performing on a daily basis? At our hospitals, the lack of any substantial reduction in sentinel events or 'near misses' — even with the checklist audits — indicated that we needed a better

tool to ensure that our surgical teams were consistently checklist compliant.

Northwell found that tool with the RVA technology developed by Arrowsight, a software company we had previously partnered with to improve hand-hygiene compliance. In a study published in *Clinical Infectious Diseases* in 2012,[11] we described how using Health Insurance Portability and Accountability Act of 1996 (HIPAA)-compliant third-party RVA, combined with real-time feedback, in a pilot intensive care unit (ICU) increased hand-washing compliance from under 10 per cent to over 90 per cent within just four weeks.[12] The de-identified team-driven system provided constructive feedback that inspired the OR personnel to collectively do better. Nobody got reprimanded or fired. Simply by providing on-site feedback, in near real time, as to how well the group was doing as a whole, we were able to change culture and performance in a way that was sustainable: nearly ten years later, RVA cameras are still in our ICUs and our clinicians perform at greater than 85 per cent compliance.

We tested RVA with hand hygiene because no one can refute the importance of washing our hands before and after patient encounters in the ICU, or the impact that hand hygiene has on nosocomial infections. When provided with near real-time feedback through this RVA technology (known as NAPA Peak Performance[13]), the group found an esprit de corps that motivated them to seek higher compliance scores on the feedback boards posted for everyone to see. The 'secret sauce' that makes this system effective is the feedback that engenders behaviour change, because, of course, the objective is not the score, but driving the action that earns the score.

What is 'near real time'? RVA employs human auditors who always review multiple monitors at a time. Each auditor is specifically trained by audit type (ie 'patient in'), and typically handles up to 12 cases per day. The auditors are watching anonymous sites and ORs, unaware of any hospital campus or location. Provided with metrics to watch for — such as drape up, drape down, patient in, patient out (or any metric that an independent auditor can look at as a binary function or accounting function) — the auditor will scan the monitor screens in 2-minute intervals for whatever they are measuring. If they see any change in the metric, they rewind 2 minutes and review the video footage second by second to retrieve full details for the desired metric(s). Because that process takes approximately 4–5 minutes to complete and report out to the status and feedback boards (and/or send customisable, discipline-specific text messages), we describe this as 'near real time' to account for those few minutes of delay in communication.

Sharing RVA feedback data with our medical staff has revealed that clinicians generally and truly believe they are 100 per cent compliant (and any lack of compliance must be attributable to someone else on the team); so, when we report actual results in aggregate to the OR group, it reinforces that our intent is not to penalise any one individual, but to change culture and productivity by helping people overall take ownership of their actions. Clinicians have learned to trust and accept the RVA data because Arrowsight regularly and randomly audits its auditors for quality assurance (QA), and has proven its reliability over time. For example, in September 2021, only 62 metrics out of 5,478 (1.1. per cent) were misclassified. This rate was consistent for the first 10 months of 2021, in which a QA review of 43,773 audits revealed 521 incorrect or missing metrics, producing an overall error rate of 1.2 per cent. Supported by these analytics, promoting change management is only one of the many benefits that have accrued to Northwell with NAPA Peak Performance.[14]

PROTECTING PATIENT PRIVACY IN THE OR: THE LOW-RESOLUTION SOLUTION

When our anaesthesia department first presented the RVA technology to Northwell's surgeons, they were understandably concerned. How do you

Figure 2: A still image from the low-resolution video used in NAPA Peak Performance, third-party remote video auditing (RVA).

Source: Report on the burden of endemic health care-associated infection worldwide. Geneva: World Health Organization; 2011. (http://apps.who.int/iris/bitstream/handle/10665/80135/9789241501507_eng.pdf?sequence=1, accessed 22nd July, 2019).

bring RVA into the OR while maintaining HIPAA compliance, respecting patient privacy and ensuring that surgeons will not be punished for anything that does or does not happen in the OR?

The answer is low-resolution (low-res) video, which makes it impossible to discern individuals and any identifying characteristics, such as tattoos or birthmarks (Figure 2). Although the initial video recorded in the RVA system is high resolution (hi res), it is instantly converted to low res, which reveals just enough visual information for an auditor to screen for the defined metrics. This is the most important step in obtaining de-identified data. We do not need, or want, to know anything about who the people are in the room; the auditors only need to see whether the group is compliant with the target metric(s).

Clinicians are also assured by the fact that the information derived from RVA is protected under the quality umbrella; therefore, it is not discoverable in any legal action. Furthermore, the original hi-res video is protected in a locked cabinet that is accessible only by a third-party security firm. No one in the hospital has a key to that cabinet. We maintain an agreement with Arrowsight that prohibits hospital staff from viewing the live hi-res tape, except in a real emergency situation. Finally, every hi-res video is permanently taped over after 24 hours, never to be seen again. These physical protections enabled us to secure buy-in from all of our practitioners involved in piloting this project.

THE IMPACT OF RVA ON PATIENT SAFETY METRICS

Once we solved for 'how' to bring RVA safely into the OR, we had to be clear about 'why' we should pursue this strategy. RVA is first and foremost a tool for patient safety: we are convinced of the importance of the SSC, and driving compliance is paramount; yet, RVA also enables hospitals to do good (what is right for the patient) and do well (promote profitability), by facilitating faster room turnovers and speeding patient throughput. At Northwell hospitals, we found that the more ways in which we used RVA with feedback, the more applications we discovered for its use.

The safety metrics related to the checklist illustrate how we obtain the data that literally

raises the bars for compliance. For sign-in, time-out and sign-out metrics, we begin with a yellow card help up in the OR that signals the start of the process to the RVA auditor. Although we have all memorised the checklist questions by now, our clinicians still read it every time. In our simulation lab we learned that it takes a minimum of 30 seconds to read all the line items for the sign in and the sign out, and a minimum of 60 seconds to do the time out. (To anyone who balked at the total 2-minute time to read through the checklist, we responded that 2 minutes is not too long to ensure the safety of our patients.)

While the clinician is reading through the checklist, the auditors are only looking to see if every member of the team is engaged, or if the drape is up or down — depending on whether it is the sign in, the time out or the sign out. The auditors will also determine whether, in reading the checklist, the team has met the minimum time criterion for each section. Recognising how effective RVA proved in revealing data, we also added terminal cleaning to examine the actual discrete tasks that are involved in cleaning our ORs, and gauge our compliance with cleaning processes.

Figure 3 depicts compliance data for sign in (before drape up/minimum 30 seconds), time out (after drape up/minimum 60 seconds) and sign out (before drape down/minimum 30 seconds). In each chart, the first

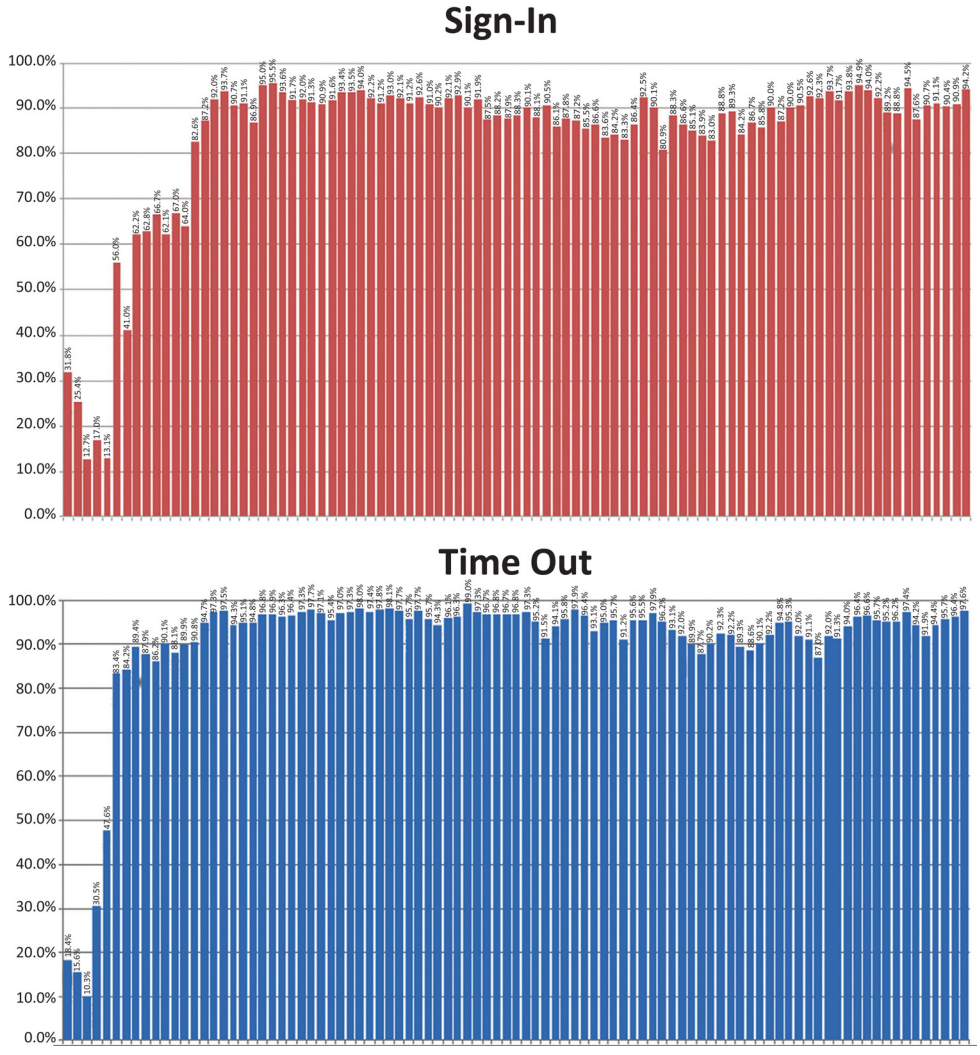


Figure 3: (*Continued*)

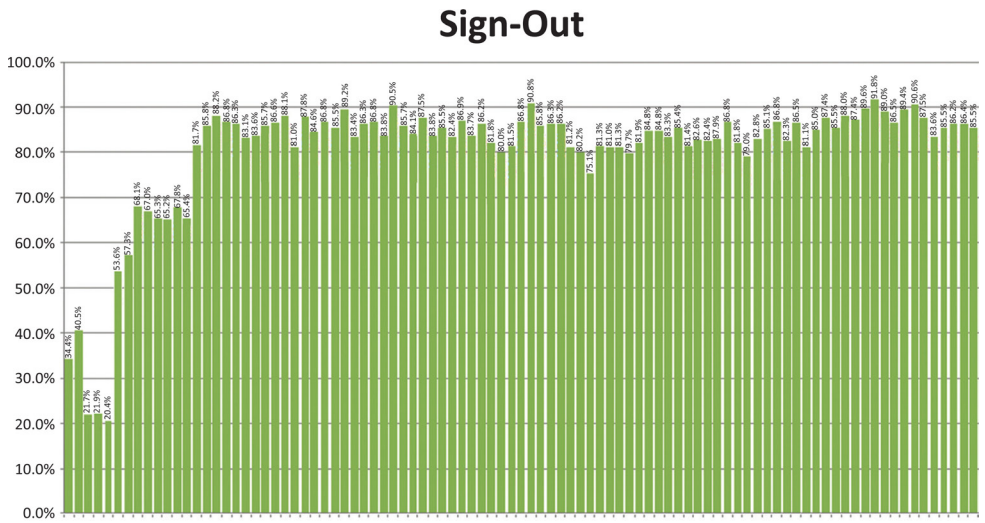


Figure 3: The impact of RVA on sign-in, time-out and sign-out safety metrics.

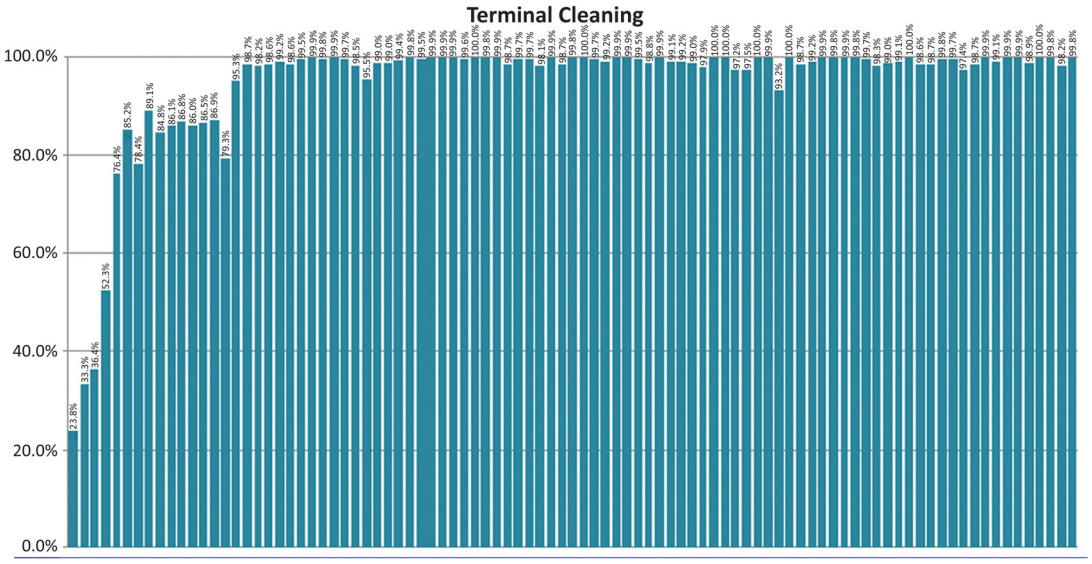


Figure 4: The impact of RVA on terminal cleaning metrics.

five bars represent three months, or more than 5,000 cases of baseline data. Discovering that we were under 20 per cent compliant was a sobering statistic that demanded a clear-eyed assessment of our need to improve. After the first 12 weeks, we turned the RVA feedback on in just half of our ORs for eight weeks, and watched as compliance rose to over 60 per cent. We then turned feedback on in all our ORs and quickly achieved sustainable compliance, generally greater than 90 per cent, in every case.

We see even more striking results for terminal cleaning (Figure 4), which now regularly reaches or nears 100 per cent. The chart depicts the rapid and sustained rise that was achieved without any punitive action. We achieved this goal simply by providing feedback to practitioners who always had the desire to do the right thing for our patients.

RVA has also proven effective in endoscopy, where auditors use hi-res video to monitor discrete tasks in cleaning processes for duodenal scopes.[15] If any step is

missed, the auditors report that back in time to prevent that scope from being used on a patient. This critical patient safety measure, which helps prevent sepsis in patients who have undergone endoscopic retrograde cholangiopancreatography (ERCP), also helps hospitals reduce related costs due to infections, such as longer inpatient length of stay and/or readmissions.

It is rare in medicine that we can improve safety. Efforts to promote safer patient care often come at the expense of efficiency, but RVA with feedback has proven to be equally valuable in creating operational efficiencies across Northwell's hospitals.

EVIDENCE-DRIVEN IMPROVEMENTS IN EFFICIENCY HELP US WORK SMARTER

When we started to talk about efficiency metrics, we did not want to look at clinical time involved in patient care. We always want our surgeons and anaesthesia clinicians to take whatever time they need for our patients' best interests and produce good outcomes. In examining metrics, our goal was not to ask people to work faster, but to identify opportunities to be more efficient between cases.

We started by analysing the time from when one patient leaves a room to when the next patient enters that room. This time period consists of three phases:

1. Patient exit to end of room cleaning, which includes two components:
   a. Patient exit to when the cleaners start
   b. Cleaning start to cleaning stop
2. Cleaning stop to room sterile (noted to the RVA auditors as mask up, opening of the first tray)
3. Room sterile to new patient in the room

Phase One can illustrate how RVA helped us implement processes that made our teams more efficient without them working harder or faster. In our old process, after the patient left the OR, the circulating nurse would tidy up, finish some paperwork and then page (or call the front desk to page) environmental services (EVS), who may have been cleaning up another room elsewhere in the hospital. This whole process might have only taken 5–10 minutes, but when you added up those minutes over every turnover, it equalled significant time in the OR.

Now, recall that we have a few minutes of delay time with RVA feedback. Here is how we converted that downtime to enhance efficiency. We learned from our auditing data that it takes approximately 9 minutes from the time the stretcher enters the room until we move the patient onto the stretcher, move the monitors and exit the room. We used that 'stretcher in room' as a signal to the auditors to notify EVS that the patient is coming out of, for example, OR #4. You can imagine how impressed our surgeons were, on exiting the OR, to find EVS waiting at the door, because we used that 4- or 5-minute delay for lead time. The circulating nurse no longer has to place the call, and the room turns over faster.

We communicate this and other vital information to everybody in and beyond the OR with real-time status boards (Figure 5) that are available on OR walls and accessible from any laptop, desktop or mobile device, to show our teams what is happening in every OR at any time.

There are endless ways that RVA can be customised to drive efficiency throughout the hospital. In one application, we looked at the time between when a room is sterile and when the patient gets into the room. You can set an alert for whatever you believe that period should be. We used the RVA auditors to observe the room situation and, when necessary, send a message to our nurse managers, anaesthesia floor leaders and front desk — not to chastise anyone, but to be proactive and offer help in the event of a patient-related or equipment-related problem. Surgeons and surgical residents also

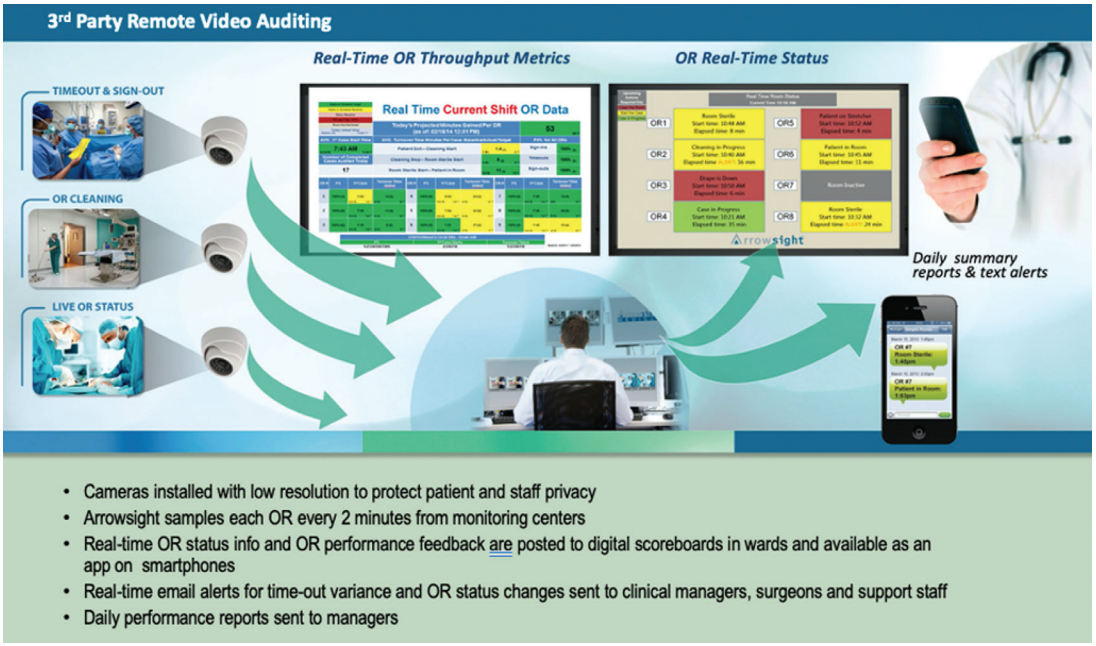


Figure 5: RVA's status boards drive OR efficiency.

appreciate that they can monitor case and room activity on their mobile phones.

Our real-time feedback boards (Figure 6) show aggregate data for the entire OR on a given day, with color-coded efficiency metrics to indicate different levels of achievement, from baseline to target to better than target. For safety metrics, we use only green and red, because you are either at 100 per cent or not. Of course, we are not at 100 per cent every day, but when we miss a safety metric in a particular room, having real-time information is significant; however, note that no individual surgeon or anaesthesiologist or nurse is ever identified. The feedback is posted for the team as a whole, which helps build and sustain a collegial culture of improvement.

Although our pilot RVA programme was focused on patient safety, it has significantly reduced the time it takes to turn over rooms, and increased on-time first-case starts. Figure 7 illustrates the steadily rising average of first-case minutes gained since LIJ expanded RVA in 2015, providing our surgical teams with real-time feedback that fosters accountability and friendly competition to be the best-performing OR.

Another example of how RVA improves efficiency — and satisfies surgeons — is in expediting X-ray into a room. Previously, when a surgeon needed an interoperative X-ray, the circulating nurse would have to page the tech or call the front desk, and everyone waited for the tech to respond. Now, we use a white laminated card posted on the wall: when X-ray is required, a nurse flips the card to the blue side on the back; the auditors see the blue and notify X-ray, and if there is no response, it goes directly to the supervisor. The communications sent out to our teams by RVA auditors (Figure 8) optimise patient flow and surgeons' schedules, generating satisfaction from the OR to the administrative offices.

THE FINANCIAL IMPLICATIONS OF IMPROVING PATIENT SAFETY

Better patient safety outcomes have financial implications that impact a hospital's bottom line by various measures. For instance, one

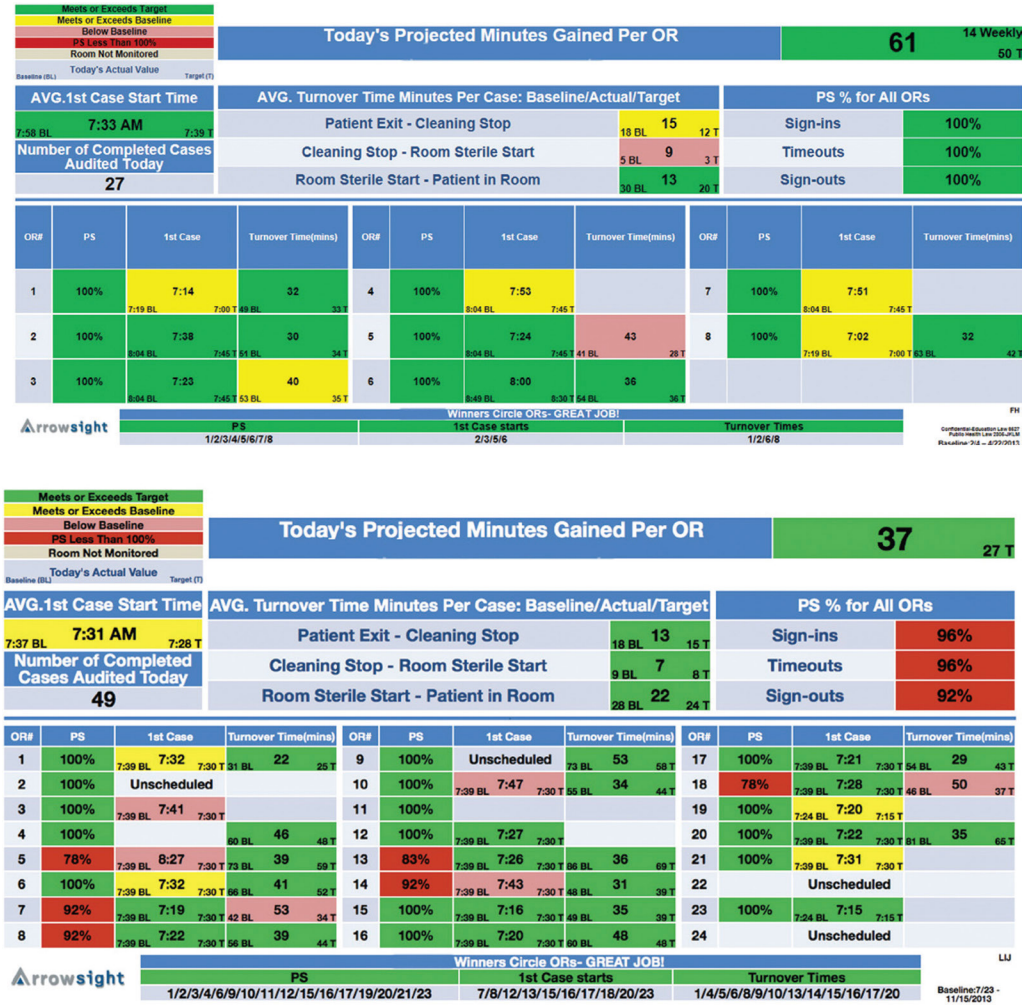


Figure 6: RVA's feedback boards create a collaborative culture for teams working together to achieve 100 per cent compliance.

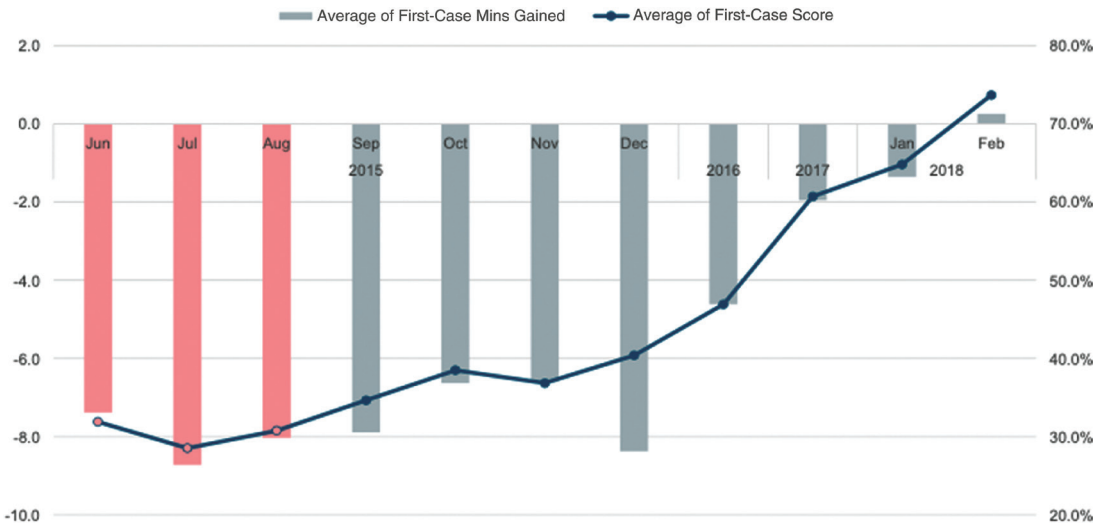


Figure 7: Improved first-case 'on-time per cent' and decreased first-case minutes delayed.

Text Alert	Team	Action
Room Sterile	Anesthesia	Room Ready
Patient in Room	Surgeon	Come to OR
Drape Down	Holding Area	Prepare Patient
Bed in Room	Housekeeping	Clean Room
X-Ray Needed	Radiology	X-ray to OR

Figure 8: Text messaging alerts reduce downtime in the OR and on hospital floors.

study showed a near 3 per cent frequency of SSIs in all surgeries, with an average additional cost of approximately US$35,000 per SSI.[16] If a hospital has 10,000 surgical cases in a year with this rate of SSI frequency, the balance sheet will show a cost of US$10m attributable to SSIs. Studies have shown that when RVA is used to improve compliance with the SSC and OR terminal cleaning, SSIs are reduced by 10 per cent. Reducing the incidence of SSIs by 10 per cent will yield a US$1m increase in savings.

RVA can also protect a hospital from the negative litigation and reputation management costs associated with non-technical errors (NTEs) such as wrong-site surgeries and retained foreign bodies. Highlighting the risk related to legal fees in just one service line, a 2015 study of NTEs in orthopaedic ORs in England and Wales estimated the combined cost of orthopaedic litigation from 2000 to 2006 to be £193,944, 167 (US$321,695,070).[17] Less tangible, but no less critical, is the immeasurable and lasting damage that a wrong-site surgery can inflict on a hospital's brand. RVA's near real-time feedback and auditors offer hospitals an effective tool to reduce the incidence of wrong-site surgeries.

Hospital administrators will find it relatively easily to quantify the value associated with higher quality patient care and OR efficiencies. After a one-time implementation fee of US$5,400 per OR, the annual cost to sustain NAPA Peak Performance[18] at a health-care facility ranges from US$10,000 to US$12,000, depending on the total number of ORs at a site. Subject to a number of variables, the cost of OR time can be estimated at US$100 per minute[19]; thus, when we decrease turnover times by 16–20 per cent, which provides opportunities for new revenue due to increased case volume, the net gain can be easily calculated, and the return on investment can be readily realised. Related financial gains may derive from a decrease in overtime and labour expenses, and increased surgeon satisfaction.

Better utilisation of our facilities also drives better financial outcomes. Another customisable feedback board populated with RVA data is a daily utilisation board that provides a quick snapshot of volume, efficiency, room use, safety metrics and idle time for each of our Northwell sites (Figure 9). Deviations in extended turnover times prompt a root-cause analysis. Idle times prompt opportunities to put more cases in specific rooms, driving increased revenue.

RVA EXPANDS ED CAPACITY, REDUCES PATIENT HOLD TIME BY 50 PER CENT

After experiencing the transformative impact that RVA technology had on our ORs,

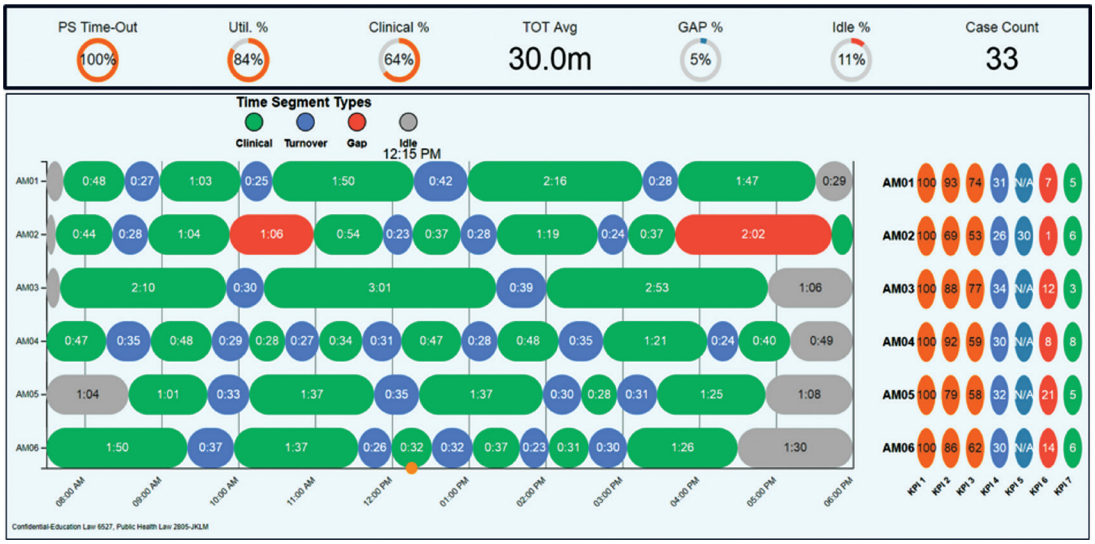


Figure 9: RVA's OR utilisation board features customisable key performance indicators that are updated throughout the day.

we wondered how we might deploy it to solve other problems. We invested in more RVA systems to boost safety and security, and leveraged our investment by auditing compliance for personal protective equipment (PPE) in isolation rooms; however, our biggest long-term problems were around the areas of capacity and patient flow.

LIJMC is a large academic teaching hub comprising five hospitals with more than 5,600 employees, including 4,000 physicians with admitting privileges. The single adult acute care hospital has 583 beds accommodating approximately 40,000 people annually who spend at least one inpatient night. In a typical year, LIJMC births 9,500 babies, the most in New York State. In atypical 2020, which saw a decrease in elective surgeries due to the pandemic, the hospital still performed about 13,000 ambulatory surgeries and 9,000 inpatient procedures. Because of the hospital's proximity to the John F. Kennedy airport in Queens, where many travellers from abroad enter the United States, it was the American epicentre of both the H1N1 and COVID-19 pandemics.

Since 2007, the number of people seen in the ED at LIJMC grew from 40,000 to 100,000 annually in 2018 through 2020, stemming from a confluence of the 2009 closure of five nearby hospitals, the pandemic, regional demographics and a strong reputation for delivering excellent patient care. (Volume declined in 2020 due to shut downs related to COVID-19.) Concurrently, the hospital's physical ED capacity grew from 65,000 in 2007 to 85,000 in 2015, when we began utilising RVA to help us better understand what was happening throughout our ED. Armed with data about how efficiently we were utilising ED rooms and facilitating patient flow, by 2019 we had increased capacity to 105,000, without adding new space. During these years, rapid growth, coupled with occupied beds, meant that patients were waiting in the ED for far too long, often up to 18 hours. We call this 'ED hold'.

LIJMC had traditionally combated ED hold by reducing excess days in a patient's length of stay (LOS). To calculate excess days, we take the average LOS by diagnosis, as defined by the U.S. Centers for Medicare & Medicaid Services. We then match that up against every patient who had that diagnosis and was discharged from our facility, and compare the LOS to determine whether we need to change a programme in some way to achieve optimal LOS outcomes; however,

in analysing our data across a decade, we found that although we had made significant progress in reducing excess days, the ED hold time remained consistent until 2019, when we embraced RVA technology to make systemic improvements.

Recalling how RVA auditors expedited room turnovers, we asked Arrowsight to help us speed up patient flow from the ED to the inpatient floors. First, we used RVA to visualise the stages and times involved between when a patient exited a room and when the room was ready for the next patient, on the inpatient units. Prior to any intervention, we learned that, on average, it took 40 minutes from the time a patient left the room till one of our team members entered that room's availability into the right IT system. It then took another 70 minutes before an EVS team entered the room to clean it. We defined this total of 110 minutes as waste (although it includes about 26 minutes of the time that EVS is actually cleaning the room). More troubling was the 735 minutes — 12 hours — of idle time that the room remained empty after cleaning.

We found opportunity in the overlap between the 18 hours of ED hold and the 12 hours of idle room time. Using RVA interventions, early in Phase One we gained 223 minutes, allowing patients to move into rooms nearly 4 hours faster and thus enabling better patient experiences (Figure 10).

In Phase Two, we are developing an electronic bed-matching algorithm that integrates RVA data with input from our clinical team and throughput nurses in the ED. Because we had previously developed a hospital zone approach to identifying every bed at LIJMC, we can now use the algorithm to automatically propose appropriate beds to our bed managers, saving them hours of manual labour, and improving turnaround time for our beds.

We achieved even better results in room turnover after instituting an RVA protocol that alerts us when a patient leaves the hospital with one of our Emergency Medical Technician (EMT) partners. RVA auditors use a visual cue to identify EMT workers approaching a room with a stretcher or wheelchair, and then notify EVS to send a team to clean the room, again reducing the waste time. In total, RVA interventions since January 2019 have enabled us to reduce ED hold time by nearly 50 per cent (Figure 11).

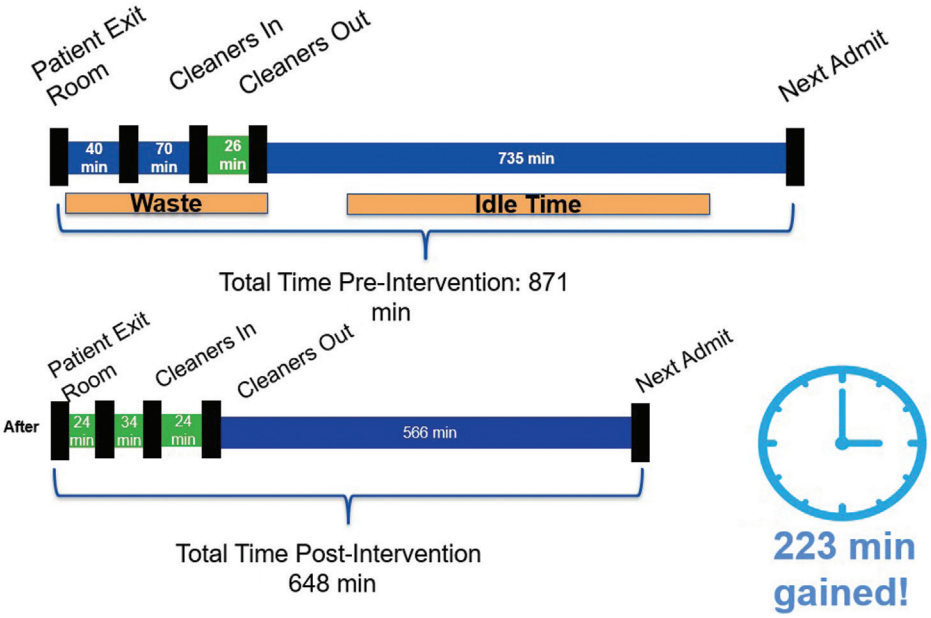


Figure 10: RVA interventions enabled LIJMC reduce room turnover time by 223 minutes.

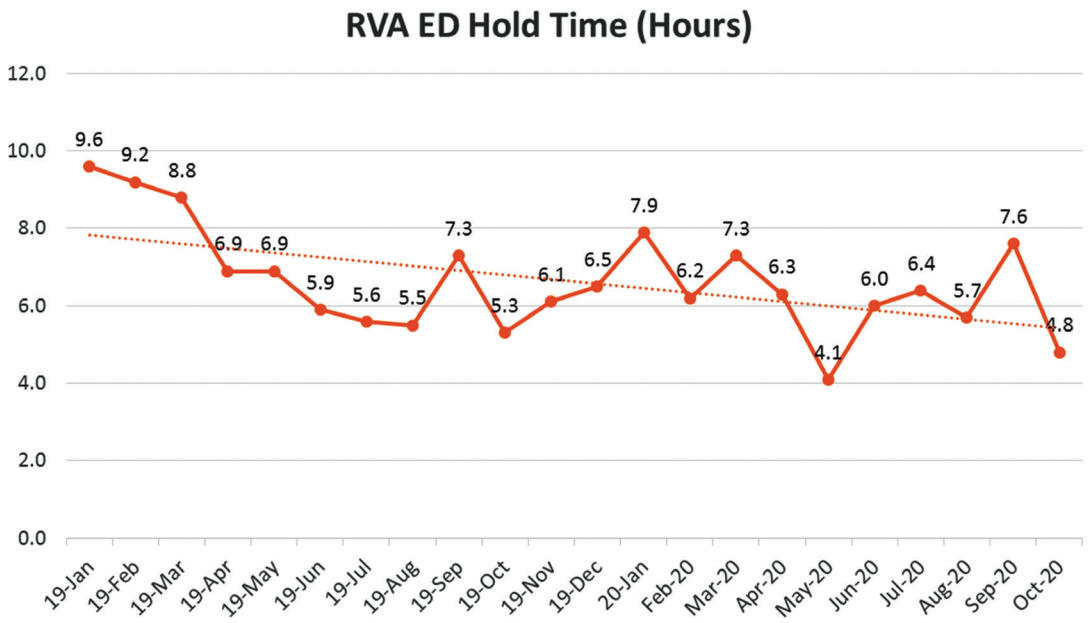


Figure 11: RVA interventions enabled LIJMC to reduce ED hold by nearly 50 per cent, speeding patient flow and increasing patient satisfaction.

Although patients now wait less than 5 hours, we will work to continuously improve until we reach our goal of zero wait time.

CONCLUSION

Boarding is a hospital-wide problem that affects the care and experience of all patients in the ED. In a consumer marketplace, those unhappy experiences become negative reviews that can have a lasting impact on culture and brand. Like many of the challenges confronting hospital managers, boarding cannot be solved with a single solution.

Solving for throughput requires coordination, collaboration and transparency from all departments, along with leadership buy-in, accountability and team-wide recognition about the area of focus. Furthermore, any investment in technology and process improvement must consider sustainability.

Traditional approaches provide a solid foundation, but we believe the answers to ongoing challenges, such as advancing quality, safety, compliance and capacity, will increasingly be found in innovative, interdisciplinary approaches like RVA. Our conviction was reaffirmed during 2020, when at five hospital campuses that surged with COVID-19 patients, RVA technology enabled Northwell to maintain greater than 90 per cent time-out compliance during a period when our practitioners were tested in unprecedented ways. This one data point exemplifies a spectrum of improvements that we achieve with RVA to continuously promote patient safety and operational efficiencies that create better experiences for all our stakeholders.

Can consistent compliance adherence be achieved without RVA? A 2016 systematic review of 26 international studies reporting on compliance with the WHO SSC found wide variation in the actual observed checklist-completion rate, noting, for example, poor performance for sign out at <50 per cent. The authors observed, 'SSC compliance varies significantly across studies, being highly dependent on staff perceptions, training, and effective leadership'.[20]

An RVA platform such as NAPA PeakPerformance[21] offers hospital leadership evidence-based tools that drive culture change by aligning staff perceptions around the common goal of delivering safer patient care. At LIJMC, our SSC compliance is measurably and sustainably higher than it was before RVA implementation because our OR teams now have the feedback that enables them to ensure compliance in every case, every day. Happier surgeons and higher case volumes are value additions that suggest even more ways we can tap the potential of RVA to help our hospitals thrive.

References

1. Haynes, A. B., Weiser, T. G., Berry, W. R. *et al.* (2009) 'A surgical safety checklist to reduce morbidity and mortality in a global population', *The New England Journal of Medicine*, Vol. 360, pp. 491–499.
2. World Health Organization. (2011) 'Report on the burden of endemic health care-associated infection worldwide', WHO, Geneva, available at: http://apps.who.int/iris/bitstream/handle/10665/80135/9789241501507_eng.pdf?sequence=1 (accessed 22nd July, 2019).
3. Shekelle, P.G., Wachter, R.M., Pronovost, P. J., Schoelles, K., McDonald, K. M., Dy, S. M., Shojania, K., Reston, J., Berger, Z., Johnsen, B., Larkin, J.W., Lucas, S., Martinez, K., Motala, A., Newberry, S. J., Noble, M., Pfoh, E., Ranji, S. R., Rennke, S., Schmidt, E., Shanman, R., Sullivan, N., Sun, F., Tipton, K., Treadwell, J. R., Tsou, A., Vaiana, M. E., Weaver, S. J., Wilson, R., and Winters, B. D. (2013) 'Making health care safer II: An updated critical analysis of the evidence for patient safety practices', Comparative Effectiveness Review No. 211, Prepared by the Southern California-RAND Evidence-based Practice Center under Contract No. 290-2007-10062-I, AHRQ Publication No. 13-E001-EF, Agency for Healthcare Research and Quality, Rockville, MD, March, available at: www.ahrq.gov/research/findings/evidence-based-reports/ptsafetyuptp.html (accessed 23rd July, 2019).
4. Patient Safety Fact File. (2019) 'Patient safety and risk management service delivery and safety', World Health Organization, September, available at: https://www.who.int/features/factfiles/patient_safety/patient-safety-fact-file.pdf?ua=1 (accessed 23rd July, 2019).
5. Slawomirski, L., Auraaen, A., and Klazinga N. (2017) 'The economics of patient safety: Strengthening a value-based approach to reducing patient harm at national level', OECD, Paris, available at: http://www.oecd.org/els/health-systems/The-economics-of-patient-safety-March-2017.pdf (accessed 23rd July, 2019).
6. Agency for Healthcare Research and Quality. (2016) 'National scorecard on rates of hospital-acquired conditions 2010 to 2015: Interim data from national efforts to make health care safer', in: Quality and Patient Safety [website], Rockville, MD, available at: https://www.ahrq.gov/professionals/qualitypatient-safety/pfp/2015-interim.html (accessed 23rd July, 2019).
7. National Quality Forum (NQF). (2009) 'Safe practices for better health care-2009 update: A consensus report', NQF, Washington, DC.
8. *Ibid*.
9. Overdyk, F. J., Dowling, O., Newman, S. *et al*. (2016) 'Remote video auditing with real-time feedback in an academic surgical suite improves safety and efficiency metrics: A cluster randomized study', *BMJ Quality & Safety*, Vol. 25, No. 12, pp. 947–953.
10. Joo, S., Xu, T., and Makary, M. A. (2016) 'Video transparency: A powerful tool for patient safety and quality improvement', *BMJ Quality & Safety*, Vol. 25, pp. 911–913.
11. Armellino, D., Hussain, E., Schilling, M. E. *et al.* (2012) 'Using high-technology to enforce low-technology safety measures: The use of third-party remote video auditing and real-time feedback in healthcare', *Clinical Infectious Diseases*, Vol. 54, No. 1, pp. 1–7.
12. Makary, M. A. (2013) 'The power of video auditing: Taking quality to the next level', *JAMA*, Vol. 309, No. 15, pp. 1591–1592.
13. *World Health Organization.*, ref. 2 above.
14. *Ibid*.
15. U.S. Food and Drug Administration. (2015 October 5). FDA orders duodenoscope manufacturers to conduct postmarket surveillance studies in health care facilities [Press release].
16. https://wayback.archive-it.org/7993/20180126064842/https:/www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm465639.htm (accessed 23rd July, 2019).
17. Shepard, J., Ward, W., Milstone, A. *et al.* (2013) 'Financial impact of surgical site infections on hospitals: The hospital management perspective', *JAMA Surgery*, Vol. 148, No. 10, pp. 907–914.
18. Harrison, W. D., Narayan, B., Newton, A. W., Banks, J.V., and Cheung, G. (2015) 'Litigation costs of wrong-site surgery and other non-technical errors in orthopaedic operating theatres', *Annals of The Royal College of Surgeons of England*, Vol. 97, No. 8, pp. 592–597. doi:10.1308/rcsann.2015.0045.
19. *World Health Organization.*, ref. 2 above.
20. Pedersen, A., Ritter, E. G., Beaton, M., and Gibbons, D. (2017) 'Remote video auditing in the surgical setting', *AORN Journal*, Vol. 105, No. 2, 159–169.
21. Wangoo, L., Ray, R. A., and Ho, Y.-H. (2016) 'Compliance and surgical team perceptions of WHO surgical safety checklist; systematic review', *International Surgery*, Vol. 101, No. 1–2, pp. 35–49. doi: https://doi.org/10.9738/INTSURG-D-15-00105.1.
22. *World Health Organization.*, ref. 2 above.