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EDITOR'S CHOICE

Improving on-time start for iMRI neurosurgeries

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ABSTRACT

Background: In the Singapore General Hospital, intraoperative MRI (iMRI) neurosurgery is a multi-disciplinary process that involves staff from multiple departments. However, a baseline analysis showed that only 10.5% of iMRI neurosurgeries start on time, resulting in unnecessary waste of resources. The project aimed to improve the percentage of on-time start iMRI neurosurgeries to 100% within nine months.

Materials and Methods: Clinical Practice Improvement methodology was used. The project involves four phases: Diagnostic, in which a baseline analysis is conducted; Intervention, in which problem areas are identified; Implementation, in which potential solutions are implemented; and sustaining, in which strategies to sustain gains are discussed.

Results: The percentage of on-time start cases gradually increased to 100% in eight months, and was sustained above 85% in the following five months.

Conclusion: This project serves as a successful demonstration of how quality improvement can be effected in a complex, multidisciplinary workflow, which is the norm for many hospital procedures.

Key words: Clinical practice improvement, intraoperative magnetic resonance imaging, neurosurgery, Singapore healthcare, quality improvement

Introduction

Intraoperative Magnetic Resonance Imaging (iMRI) was first developed in 1995, and has since become a major development in modern day neurosurgery.[1] With iMRI, three-dimensional, high-resolution MR images can be captured throughout the course of an operation. This allows the surgical team to detect and respond immediately to brain shifts and complications such as hemorrhage that may occur during the operation. In brain tumor surgery, iMRI also allows for the extent and adequacy of tumor resection to be intraoperatively evaluated. This minimizes the need for repeat surgery for the removal of residual tumor.[2]

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Since 2008, Singapore has joined few countries around the world that offers iMRI capabilities.[3] With the installation of the BrainSUITE iMRI system in its Major Operating Theater complex, the Singapore General Hospital became the first hospital in Southeast Asia to house a facility of this nature.[4]

In this paper, the authors describe a Clinical Practice Improvement (CPI) project that aims to improve the percentage of neurosurgeries that start on time in the iMRI Operating Theater (OT) in the Singapore General Hospital. A positive outcome in this project enables manpower and resources to be more efficiently utilized, leading to cost savings and improvements in both patient welfare and staff morale. For patients and their families, anxiety is alleviated when pre-surgical preparation proceeds smoothly and waiting time is minimized. Staff, on the other hand, benefit through the reduction in over-time and extra work shifts.

CPI is a Quality Improvement (QI) methodology that develops evidence-based procedures to achieve optimal clinical outcomes at minimum essential cost over the continuum of care. CPI measurement involves a comprehensive systemic view of the healthcare management process, encompassing patient characteristics, work processes, and outcomes. All three classes of data are simultaneously considered, so that significant associations between process and outcome can be meaningfully analyzed.[5]

The CPI project was conducted in four phases. In the Diagnostic phase, a baseline analysis was carried out to assess the severity of the problem. This was followed by the Intervention phase, in which a range of QI tools were used to identify potential areas for improvement. Possible solutions to these areas for improvement were then proposed and implemented in stages during the Implementation phase. Throughout this phase, data was continuously collected and analyzed to evaluate the effectiveness of the implemented measures. In the final phase, strategies for Sustaining the gains of the project were discussed.

Materials and Methods

Diagnostic phase

Across seven weeks from 8th September to 27th October 2009, the team recorded the starting times of all neurosurgeries occurring in the iMRI OT. Out of the 19 neurosurgeries that took place during this period of time, only two (10.5%) started on time at 8.30 a.m. From this baseline analysis, it was evident that there was room for improvement.

The objective of the CPI project was to achieve 100% on-time start for neurosurgeries in the iMRI OT within 12 months. A neurosurgery in the iMRI OT is a multi-disciplinary endeavour, involving preparatory work from four groups of medical professionals—the surgeons, anesthesiologists, radiographers, and OT nurses. In addition, the patient must be readied for surgery. "On-time start" is therefore defined as having all five 'flags'—the surgeon, anesthesiologist, radiographer, OT nurses and patient—checked and ready in the iMRI OT by 8.30 a.m.

In addition, the 100% on-time start target excluded the following cases: Cases scheduled for a late start, local anesthesia cases, intubated ICU cases, angiography cases, and pediatric cases that were transferred from another local hospital. These cases involved unique work processes that deviated from the normal workflows, and were not included in the scope of this project. The use of the term "case" in the rest of the present paper therefore refers only to the targeted cases, and excludes the exceptions listed above.

The project team included representatives from the four major departments involved in neurosurgery in the iMRI OT. Specifically, the team comprised a senior consultant, consultant and nurse clinician from the Department of Anesthesia; two registrars from Neurosurgery; one senior staff nurse from the OT and another from a neurosurgical ward; one senior radiographer from Diagnostic Radiology; a senior executive from the Department of Clinical Governance and Quality Management; and an executive from the Service Operations Unit.

Intervention phase

Firstly, the team charted out all key work processes that occur from pre-surgical preparatory work to the start of the operation in the iMRI OT. As seen from [Figure 1], all five 'flags' have their own unique workflows, with multiple flow processes running concurrently and independently from one another. It must be noted that some of the workflows start on the day before the operation, and continue on the day of the operation until the time of entry into the OT.

With the aid of the process flowcharts, the team then brainstormed to identify potential factors that could delay the start time of the neurosurgery in the iMRI OT. As a disruption in the workflow of any one of the 'flags' will impact the starting time of the surgery, the team specifically examined the workflows of each 'flag' for possible causes of delay. In addition, the team also considered systemic factors such as those related to facilities or the IT system. The results of the team's brainstorming session were then organized into an Ishikawa cause-and-effect diagram [Figure 2].

Next, the team went through a few rounds of multivoting to narrow down the most promising factors for intervention. Voting results were collated and organised into a Pareto chart [Figure 3], which is a QI tool that aids in singling out the top 20% of factors causing 80% of the problem. As seen from [Figure 3], the top five factors identified were: a) Incomplete or missing checklist of the patient, b) ICU bed not available, c) Surgeons doing rounds and therefore late for surgery, d) Porters late, and e) Results of blood test not available on time.

Implementation phase

Specific intervention strategies were proposed for each of the five main factors, and implemented in stages over time. The time points at which specific measures were implemented are presented in Table 1. The factors and intervention strategies devised for each factor are discussed in greater detail below.

Incomplete or missing checklist of the patient

Due to the use of the extremely strong magnetic field in the iMRI OT, iMRI surgery requires an additional pre-operative safety checklist, over and above the usual checklist and consent form required for standard operations. When neurosurgical wards are full, patients are situated in non-neurosurgical wards before their operation. As nurses in non-neurosurgical wards are often unfamiliar with the iMRI protocol, patients who are sent down from these wards often have the additional iMRI checklist missing or incomplete.

To overcome this factor, it was proposed that the neurosurgical doctor who clerks the case the day before the operation must ensure that the checklist is available and inserted into the patient's case file during consent-taking.

ICU bed unavailable

An ICU bed is required for the patient after the operation. When there are no ICU beds available on the day of operation, the operation has to be cancelled. Confirming the availability of the ICU bed often causes delay on the morning of the operation,

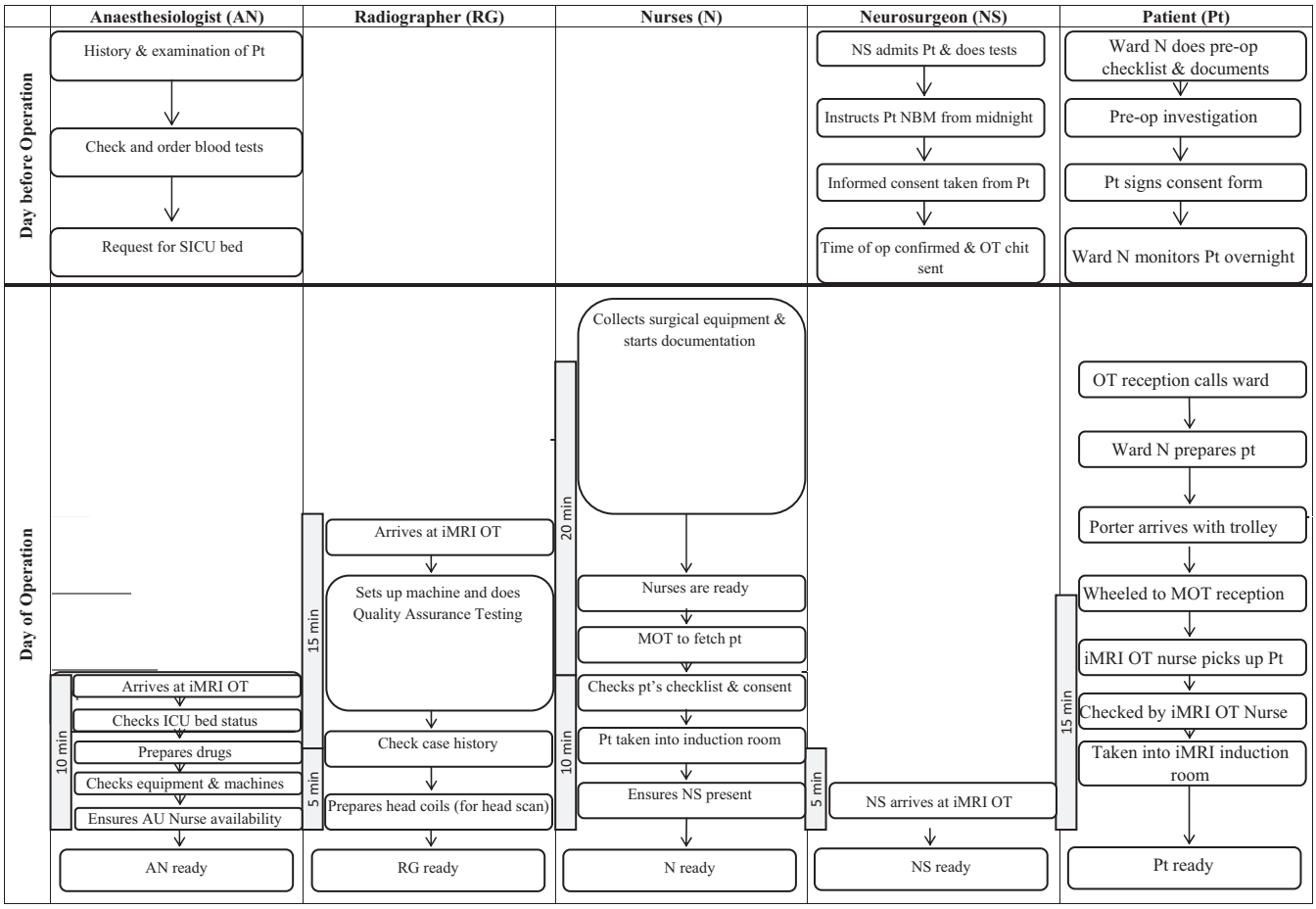

Figure 1: Process flowchart showing the workflows of all five 'flags' prior to neurosurgery in the iMRI OT

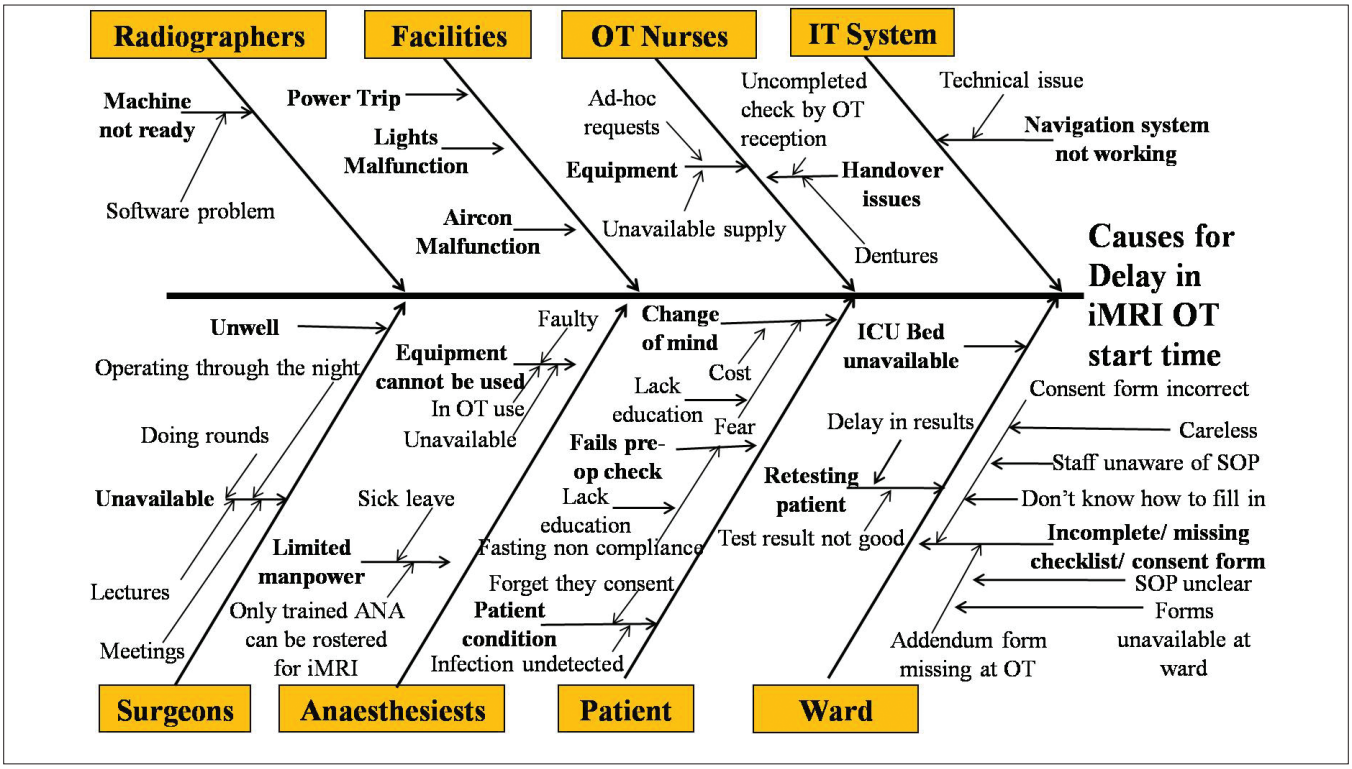

Figure 2: Ishikawa cause-and-effect diagram showing the possible factors that may result in a delay in iMRI surgery start time

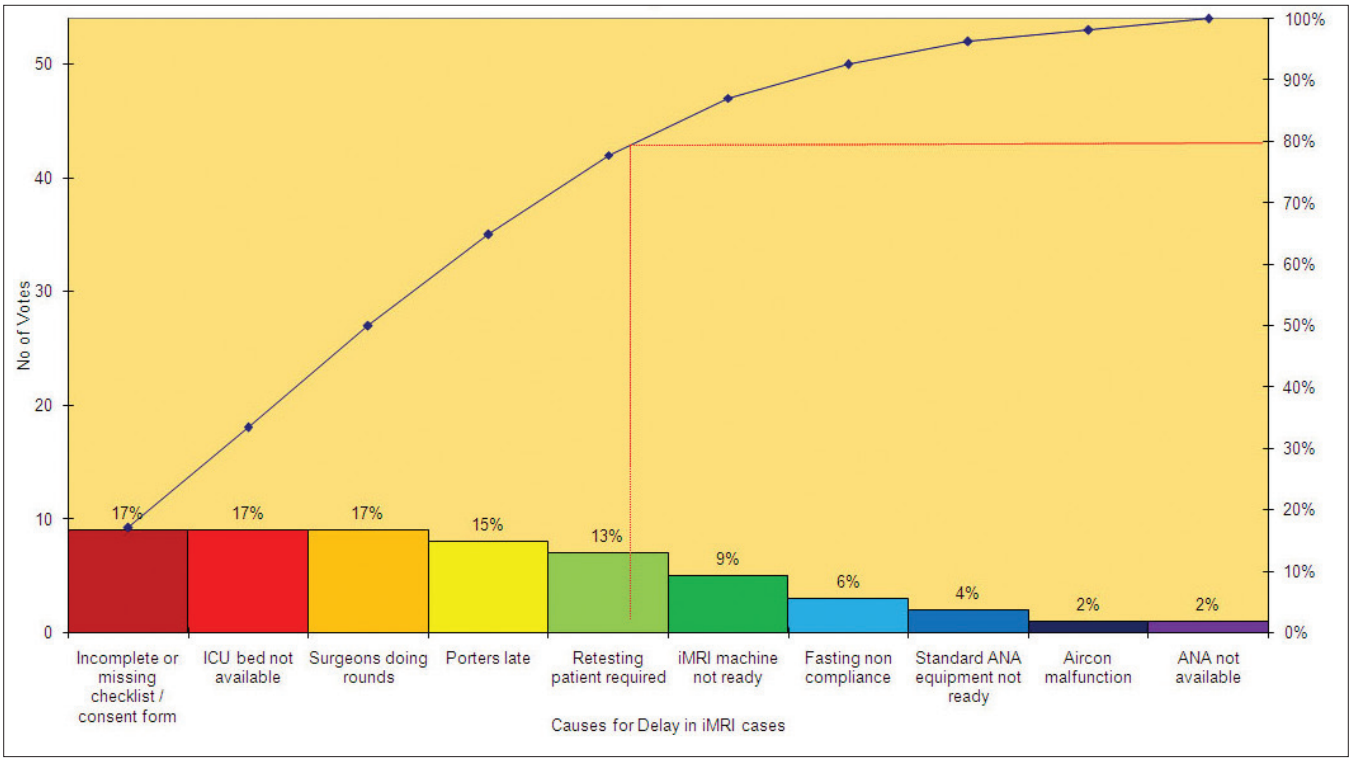

Figure 3: Pareto chart showing the team's multivoting results on the top factors that result in a delay in iMRI surgery start time

Table 1: Time points at which each intervention measure was implemented

Date	Measures implemented	Factor engaged
30 Oct 2009	1st reminder to neurosurgeons regarding 8.30 a.m. start time Awareness of project raised among MOT staff	Surgeons doing rounds porters late
3 Nov 2009	Neurosurgeon to start checklist when clerking case	Incomplete or missing checklist of the patient
16 Nov 2009	Porters to prioritize iMRI patients as 1st case 2nd reminder to neurosurgeons regarding 8.30 a.m. start time	Porters late Surgeons doing rounds
27 Nov 2009	On-call team to follow up on results of blood test	Results of blood test not available on time
17 Dec 2009	Neurosurgeons to pre-inform iMRI OT team on ICU bed availability. Results of repeat blood test to be available by 7 a.m. latest on morning of operation	ICU bed unavailable Results of blood test not available on time
3-28 Feb 2010	Instructions for compulsory patient site marking in neurosurgery	Implementation of operative site marking
26 Feb 2010	Verbal reminder to new medical officers and registrars regarding checklist and being on time Reminder email sent to medical officers and registrars regarding the above	Rotation of postings for medical officers and registrars
6 April 2010	Implementation of colored card system	rurgeons doing rounds
6 May 2010	Information package for new medical officers and registrars	Rotation of postings for medical officers and Registrars

and results in an unnecessary waste of resources when the operation has to be cancelled at the last minute due to the unavailability of beds.

It was thus proposed that neurosurgeons should pre-inform the iMRI OT team on the ICU bed availability preferably on the night before the operation. Often, this was not possible, due to emergency admissions through the night, so it was decided that the neurosurgeons should confirm ICU bed availability latest by 7.30 a.m. on the morning of the operation, to allow sufficient time for pre-surgical preparation.

Surgeons doing rounds

At times, the neurosurgeons come in late to the OT because they are occupied with doing rounds. To circumvent this issue, it was proposed that emails be sent to the neurosurgeons through the Head of the Department of Neurosurgery, reminding them of the start time of iMRI neurosurgeries and the importance of punctuality.

To increase a sense of ownership and accountability among staff across all five 'flags', a colored card system was proposed. In this system, five colored cards representing each of the

'flags' are displayed on a board at the entrance of the iMRI OT. There are two rows on the board, labeled 'Out' and 'In', for the cards to be slotted in. When a particular 'flag' is ready, staff will slot the 'flag's card into the 'In' row. Each card is also filled up with information such as the check-in time of the 'flag' to the OT, and reasons for delay if there was one.

Porters late

On the morning of the operation, the Major Operating Theater (MOT) reception will contact the patient's ward to get the patient prepared for surgery, as well as call up a porter to deliver a trolley bed to the ward. On receiving the call, the ward nurse will put the patient through the necessary preparation. The patient is then wheeled to the MOT reception area by the ward nurse and porter.

There are only two porters serving all the MOTs. Due to the lengthy pre-surgical preparation required for iMRI cases, porters often left the iMRI cases to the last.

The team thus sought the support of the Head of the Department of Neurosurgery to issue a standing order for porters to prioritise iMRI cases. To gain the support of all staff involved, awareness of the project was raised among nurses from the MOT and neurosurgical wards, as well as the porters. The objective and benefits of the project were communicated to them, and nurses and porters were encouraged to work together to prioritize iMRI patients. When nurses and porters do so, they receive fewer complaints from the iMRI OT team and thus experience less frustration. This creates a positive feedback loop which motivates ward nurses and porters to sustain the efficient preparation and prioritising of patients.

Results of blood test not available in time

As seen from [Figure 1], the patient has to undergo a few pre-surgical medical tests, including blood tests, one day before the operation. Surgery may be delayed if the results of the blood tests do not come back on time, or if the tests yield abnormal results that require the patient to be retested again. If test results do not return on time, members of the surgical team have the additional task of tracing test results on the morning of the surgery, lengthening the time for pre-surgical preparation.

To ensure that test results are available in a timely manner before surgery, it was proposed that the on-call team should check that the results are back, and send the patient for retesting if necessary on the night before the operation. If retesting is required, results of the repeat test should be made available and checked latest by 7.00 a.m. on the day of the operation. This allowed the surgical team to focus on other necessary pre-surgical preparations on the morning of the operation, and prevented unnecessary wastage of the patient's and surgeon's time.

Rotation of postings for junior doctors in Singapore

In Singapore, junior doctors and registrars rotate postings among the various departments or hospitals every six months, to give them wider exposure to various conditions and treatment protocols. Every half a year, the Neurosurgery Department receives a new batch of doctors who are unfamiliar with neurosurgical iMRI protocols.

Previously, there was no formal manual available that documented the protocols pertaining to pre-operative preparation for neurosurgery in the iMRI OT. The team thus came up with an information package that collated all important information and guidelines regarding the special requirements for iMRI OT, which included the iMRI checklist, the expected timing at which the patient should be in the OT, the pre-operative procedure for preparing patients, and the timings at which the ICU bed status and blood test results should be confirmed, respectively. This new information package would be given to all new neurosurgical doctors during their orientation, in the form of a hard copy as well as an email, to aid them in familiarizing themselves with the procedures as quickly as possible.

While rotation of postings did not emerge in the Pareto chart as one of the main factors that led to delays in the start time of iMRI surgery—as it occurred only once every half a year—the team thought it was essential to address this issue, to ensure intergenerational continuity of implemented measures.

Implementation of operative site marking

Six months into the project, an unforeseen cause of delay surfaced as a result of a new initiative that was applied to all operations in the hospital. This initiative required the patient's operative skin site to be marked before the patient entered the OT, as an added precaution against the remote possibility of surgeons operating on the wrong site.

While this initiative improves patient safety, it inevitably lengthens pre-surgical preparation time, leading to a delay in the time that patients arrive at the OT. To streamline the entire process, it was proposed that pre-operative site marking should be done in the ward at the same time patient consent was being taken the night before the surgery.

Results

Figure 4 shows the impact of the CPI project on the starting time of iMRI cases in the iMRI OT, from September 2009 to November 2010. As seen from the chart, there was a general increase in the percentage of cases that started on time. While December 2010 presents with a startling 0% of target met, it must be noted that only three cases underwent surgery during this month, as opposed to the average of 13 cases that undergo surgery in other months. There is generally a

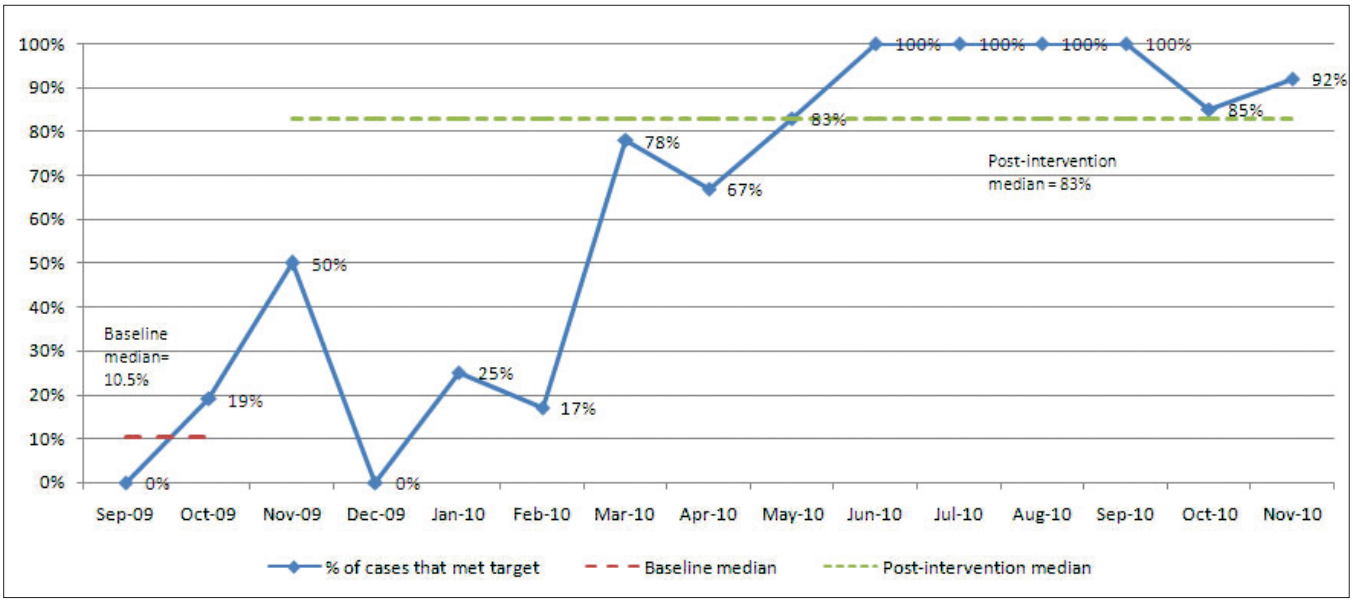

Figure 4: Chart showing the % of iMRI surgeries that started on time over the course of the project

lower caseload in December as non-urgent cases often prefer not to schedule their surgeries during the festive season. The slight dip in February is accounted for by the start of the new institutional ruling on pre-operative site marking. By June 2010, the objective was successfully met, with 100% of cases starting on time. Hundred percent on-time start was subsequently sustained for the next three months. While the percentage of on-time start cases took a slight dip to 85% in October 2010, it rebounded to 92% by November 2010. The average post-intervention median from November 2009 to November 2010 was 83%.

Discussion

The present project offers clear benefits for patients, staff, and the institution alike. Firstly, it allows for more efficient utilisation of manpower and resources. This enables a greater caseload to be covered in the same amount of time, which reduces patients' waiting time for elective surgery. In addition, when pre-surgical preparation proceeds efficiently and the surgery starts on time, patient anxiety is reduced. Both of the above outcomes aid in increasing patient satisfaction, which in turn helps to boost the reputation of the institution. Staff welfare is also enhanced. When cases start and end on time, staff lessens their exposure time in the magnetic field. As noted in the recent guidelines by the International Commission on Non-Ionizing Radiation Protection,[6] occupational exposure to static magnetic fields during MRI procedures is a concern for medical professionals, and should be limited whenever possible. Over-time and extra shifts are also reduced, improving staff morale.

Several lessons for QI implementation can be learnt from the present project. Firstly, it can be seen that iMRI pre-surgical preparation involves at least four departments and staff from various levels in the organisational hierarchy, ranging from the porter to the neurosurgeon. Such a multi-disciplinary approach is common for many hospital procedures. It is thus important for QI project teams to have representation from all the major groups of staff involved in the procedure—the present project team, for instance, is comprised of staff from the four major departments involved in iMRI pre-surgical preparation. Staff from different departments come with their own unique knowledge and viewpoint of hospital processes, and can aid in building up a multi-faceted perspective of the problem and its possible solutions. Co-opting the various departments into the QI process also fosters a sense of ownership of the project among staff and promotes inter-departmental collaboration.

While not all ground staff can be involved in the planning process due to practical considerations, it is important to gain their support for the project. As a Gallup meta-analysis demonstrated, the relationship between staff engagement and organisational performance outcomes is significant and highly generalizable across organizations.[7] When change is imposed from the top with little explanation, ground staff may show resistance. QI can only be successful if ground staff understand the need for change, and are intrinsically motivated to implement and sustain the relevant measures.[8] This can be achieved by effective communication of the objective and benefits of the project to all staff involved. As seen from the present project, communication was an integral part of the intervention process, with outreach efforts being made to staff from all levels of the hierarchy, ranging from neurosurgeons to OT and ward nurses, porters, and the MOT reception staff.

Secondly, sustainability must be a key consideration in any QI project. Sustainability is often the main challenge in

QI—research has shown that about 70% of organisational changes fail to be integrated into the system and achieve long-lasting impact.[9,10] Two strategies that were implemented in the present project to ensure sustainability were the colored card system and the neurosurgical OT package. The colored card system acts as a constant visual reminder to staff about the importance of starting on time for neurosurgeries. By openly displaying the timings that each 'flag' is ready by, the colored card system promotes accountability and ownership among all staff for the goal of starting on time. Effective measures implemented in the present project are documented in the neurosurgical OT package. As this package will be presented to all new neurosurgical doctors, it ensures that effective measures will be maintained across the turnover of staff.

Thirdly, QI sustainability relies not only on continuing the measures that proved effective during the QI project, but also on detecting and adapting to systemic or environmental changes. As seen from the present project, unexpected changes that impact service quality may occur at any time, such as new institutional rulings. It is important to continue collecting and monitoring outcome data beyond a QI project, so that any negative dip in service quality can be immediately detected and addressed.

In summary, QI involves the following critical ingredients: Multi-disciplinary collaboration, communication, adaptability, and patience. While the support of management is essential for any change process, winning the support of ground staff is equally important. In addition, it is important to note that quality improvement is a continuous process. The ability to sustain positive change across staff turnover may be the litmus test that gauges the success of any QI initiative.

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