Improving First Case Start Times in an Interventional Radiology Department

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Abstract

Problem: Delays to first case start times (FCST) are defined as the time the first scheduled patient enters the procedure room. A large urban university hospital in the mid-Atlantic region's Interventional Radiology (IR) current success rate of timely FCST was 35%, resulting in significant interruptions in treatment and reflected in 33% Press Ganey patient satisfaction scores, compared with a 58% target. **Purpose:** The aim of this project was to improve FCST (at 0800) for IR to 80%, using three interventions to address the key drivers of delayed cases: pre-op nurse arrival time, advance practice provider (APP) availability, and prioritizing inpatients as first cases. **Method:** Three of the seven procedure rooms started with a prepared inpatient procedure. Preoperative and charge nurses revised shifts started at 0630, the same time first case outpatients were instructed to arrive. Finally, priority was given for one APP to be available to answer procedure questions and consent patients. The charge nurse completed a survey daily for each 0800 procedure to measure compliance with and outcomes for these interventions. The Press Ganey Survey measured patients' overall satisfaction with their experience and their likelihood to recommend department services to others. **Results:** At the end of intervention implementation, FCST success rate increased to 56% and 'likely to recommend' and patient Press Ganey satisfaction scores increased to 77%. Adjustment of shift times resulted in 100% compliance. APP availability resulted in a 5% improvement to FCSTs. Outpatients (n=72) had more successful start times compared to inpatients (n=60) of the 237 recorded cases.

Conclusion Though the 80% goal was not achieved, the project demonstrated resiliency and adaptability seen as the interventions were still implemented daily despite challenges faced with opening a new hospital sector, staffing reallocations, and software disruptions.

Improving First Case Start Times in an Interventional Radiology Department

First case start time (FCST), defined as the time the first scheduled patient enters the procedure room, is a metric used to determine the efficiency of procedures, reduce subsequent delays, and deliver safe and quality patient care. Delays to a timely FCST are significant as they result in decreased patient satisfaction, procedure cancelations, and interruptions in treatment, which ultimately increase length of hospital stay, diminish quality of care, and increase total hospital costs (Frampton et al., 2022; Zheng et al., 2015). Late patient arrival, insufficient staffing, delays in obtaining procedural consent, insufficient procedure equipment, and incomplete laboratory results present barriers to success of FCST results (Frampton, et al., 2022).

An urban academic hospital in the mid-Atlantic region's interventional radiology (IR) department determine the goal of successful FCST, defined as a patient entering the procedure room by 0800, by the academic hospital's chief interventional radiologist. The goal set by this chief for successful FCST goal is 80%, however, the department's current success rate of timely FCST was 35% (Society of Interventional Radiology, 2022). As a result, there were significant interruptions in treatment and decreased patient satisfaction, reflected in the nationally accredited Press Ganey Survey patient satisfaction scores of 72% and a "likelihood to recommend" score of 74.8%. Major root causes of this chronic issue have been attributed to complex and time-consuming preoperative scenarios, such as difficult IV access or lack of mobility, physician and staff readiness, technology and equipment malfunctions, and emergency procedures taking precedence over scheduled procedures. Delays caused by these issues create subsequent problems in patient diagnosis treatment and care by other departments and providers. The delays also create pipeline issues for patient case ratios for the department which ultimately affect revenue for the health system. In all, when delays occur to first scheduled procedures, delays

likely will occur to each subsequent scheduled procedure, which creates a chain of events that affects not only the patient, but many other services and the health system as a whole.

Available Knowledge

A systematic literature review was conducted to identify the best recommendations in support of a practice change to improve FCST in this interventional radiology department. High quality, systematic literature reviews of randomized control trials and descriptive syntheses evaluated the methodology, Lean and Six Sigma (LSS), in various healthcare settings, including inpatient, outpatient, ambulatory care, surgical departments, and radiology departments, each in private and public healthcare organization. As seen in the evidence review table in Table 1 and evidence synthesis in Table 2, these methodologies, especially in combination were determined to be the best approach to make practical changes to a system through improving workflow, reducing variability and overall improve the quality of a system (Amaratunga & Dobranowski, 2016; Tlapa et al., 2020; Zepeda-Lugo et al., 2020). The implementation of LSS in procedural departments produced the greatest outcomes in reducing length of stay, decreased on time start times, and wait times (Nicolay, et al., 2012; Tlapa, et al., 2020; Zepeda-Luego, et al., 2020). Additionally, the literature suggests implementation of LSS is most beneficial to a multidisciplinary healthcare department's workflow, efficiency, and waste reduction.

The purpose of this Doctor of Nursing Practice (DNP) project was to improve FCST for the interventional radiology department to 80%. In doing so, three interventions were implemented to achieve this goal: pre-operative nurse and charge nurse arrival times were adjusted, an APP was designated to answer patient and staff questions and consent outpatients, and at least three procedure rooms were to start with an inpatient procedure.

Rationale

To implement this project, the Promoting Action on Research Implementation in Health Services (PARiHS) framework was used as a guide. This framework suggest that effectively putting research into practice depends on the context where the intervention will occur and the method through which evidence is integrated (NCCMT, 2021). The evidence for FCST suggests improved efficiency and workflow in a procedural setting reduces health system costs, improves patient safety and outcomes, and improves patient satisfaction. Experience and expertise from department practitioners contribute to the evidence suggesting positive impacts of timely FCSTs. For exploration of context as it relates to the PARiHS framework, improving FCST and its positive impacts are relevant to the everyday workflow of the IR department. Adequate resources, such as staffing, equipment and department size are appropriately managed by managers and chief physicians. Interdisciplinary focused implementation strategies were put in place as well. To facilitate this project's process, key stakeholders, including the nurse manager, radiation technologist manager, and chief interventionalist, have transitioned from providing support to achieve the overarching goal to enabling all staff to analyze and modify their ways of working to achieve the goal. By the nature of the high ratings of evidence, context and facilitation, successful implementation of the interventions was expected to work with the PARiHS framework.

Methods

The departments' culture, climate, and resources are contextual elements considered for the implementation of interventions to improve FCSTs. Though the IR department is a fast-paced, dynamic, and high census environment, the culture's focus is evidence-based, and patient centered. The interdisciplinary staff, comprised of nurses, technologists, residents, fellows,

attending physicians, and medical students, work as a team to promote patient safety and adopt evidence-based practices to improve patient care.

The current structures and processes related to the issue of delayed FCSTs were also evaluated in hopes to make significant change. Inpatients and outpatients who required IR resources were scheduled based on primary care provider referral, however, their progression through IR differed. Outpatients were called the day prior to their appointment by a preoperative rotating nurse to remind them of their fasting requirements, medication instructions and arrival time, which previously was 30 minutes to an hour before their scheduled procedure. Once arrived, patients were brought to a preoperative area to change, asked pre-procedural questions to indicate any posing risks, give procedural consent to an advanced practice provider (APP), see the procedural attending physician, and, if applicable, see and provide consent to general anesthesia from an anesthesiologist. Each of these steps needed to be completed before a patient was indicated 'pre-op complete' to go into a procedure room. Many factors slowed the pre-operative process for outpatients, including patient late arrival to the department, limited mobility of patients, poor vasculature when placing an intravenous catheter, limited staff to consent the patient, and obtaining laboratory specimens.

In contrast, inpatient primary teams consulted IR's APPs to review the necessity of a procedure, and if approved, were added to the week's schedule by the on-call attending physician and charge nurse. There was no designated procedural time allotted to inpatients, rather they fit into the daily schedule with the planned outpatients. When the schedule allowed, the charge nurse received a hand-off from the primary nurse and placed the patient in a transport queue to come to the department via the hospital's patient transport team. These patients 'pre-op work up'

including lab results, intravenous access, consenting, transferring the patient to a bed or stretcher, was completed by the primary nurse prior to coming to IR.

Prior to project implementation, nursing staff arrived at 0700 for their 10-hour shift. Upon arrival, their roles include prepping the procedural room for the scheduled patient, and ready the outpatients in the preoperative suite. Meanwhile, physicians and APPs reviewed each scheduled case in morning rounds, which started at 0730 in a separate space in the department. The daily schedule and patient tracking was managed through the SIR specific workflow management tool, Hi-IQ, used by all department staff to provide patient centered communication and tracking.

To achieve 80% timely FCST, several interventions were identified to address the key drivers of delayed cases: patient readiness in the preoperative area, surgical preoperative assessment, and timeliness of inpatients versus outpatients. The first intervention was to have at least three of the seven procedure rooms scheduled to start with an inpatient procedure given their quick readiness and accessibility. Next, when calling external patients to remind them of their upcoming procedure, the preoperative nurses instructed patients to arrive one hour prior to their procedure, making all first case patient arrival times 0630. Therefore, the preoperative nurse and charge nurse's shifts were revised to start at 0630 for ample patient prep and in-house transportation time. Finally, to address the delays related to patient procedural consent and questions, one APP was released from morning rounds and instead was available to fulfill these requirements.

To achieve these project goals, strategies and tactics were set in place. Accountability was achieved through revised nurse and physician roles and weekly check-ins with nursing, technologist and APPs. The compliance with these interventions and outcome goals of punctual

FCST were measured with the First Case Start Time Success Rate survey tool to collect the data (Appendix A). The charge nurse input all data points in the survey using REDCap data collection after all 0800 scheduled procedures had been marked 'wheels in' on Hi-IQ, completing a maximum of 7 surveys daily (Figure 7). De-identified information was acquired from Hi-IQ and patient's medical electronic records to complete each survey. The survey was designed to have minimal time constraints for the charge nurse, as it was comprised of a series of yes/no or multiple-choice questions to encourage 100% compliance. The measured interventions included the 'wheels-in time' of a patient, the type of patient, if an APP was present for outpatient procedures, and reason for delay, if applicable. To measure the secondary outcome goal of improved patient satisfaction, the Press Ganey Survey, sent to patients after discharge from the hospital, was used in monthly metrics to measure patient's overall satisfaction with their experience and their likelihood to recommend department services to others.

The IR department used their organization's Institutional Review Board (IRB) Office to assure the initiative of the project posed no harm or threat to participants, protected patient privacy and confidentiality, and was conducted with honesty and integrity. Prior to project implementation, mandatory CITI training courses as well as a Non-human Subject's Research determination from the Human Research Protections Office (HRPO) of the UMSOM Institutional Review Board (IRB) was obtained.

Results

Descriptive quantitative statistics and a run chart were used to draw inferences of the successes and failures of the interventions at the end of the data collection phase (MNDH, 2022). Based on the data collected in the implementation period, successful FCST increased to 53.8% after interventions were implemented (Figure 3). The presence of an APP resulted in a 5% of

patient start times to be on time. (Figure 2). Pre-op and charge nurses had a 100% adherence rate to their new shift start times. Outpatient procedures resulted in 31% on time procedures compared to inpatients, having a 25% on time procedure. (Figure 4). Additionally, Press Ganey scores for patient satisfaction and "likely to recommend" increased to 77.5% and 77.8% respectively (Figure 5).

The run chart of collected data created evaluated the trends and patterns of all intervention's effects on FCST (Figure 1). Though the FCST goal was 0800, the average "wheels in" time was 0750. There was random variation in the data points when the interventions were first implemented, however in the second half of the implementation period, there was a shift from random variation to non-random variation, seeing both positive and negative shifts, likely caused by several incidental factors that coincided with the implementation period and contributed to the observed data patterns and outcomes. These factors included new additions to the hospital causing shifts in staffing across the entire system such as patient transportation services, new scheduling software implementations, nursing hiring changes and role allocation adjustments, and unique patient delays such as limited patient mobility, poor intravenous access, and late arrival times. The initial random fluctuations in the data could be attributed to inevitable and likely unavoidable obstacles such as varying patient arrival times from home, limited mobility, challenges in obtaining intravenous access due to poor vasculature, procedural inquiries, and the timing of laboratory sample collection on the day of the procedure.
Non- random and data runs on the run chart, however, could be attributed to distinctive barriers. Over the span of 15 weeks, the inauguration of a new pavilion at the academic hospital led to the relocation of patients from intensive care units, emergency departments, and operating rooms to this new facility. Although the IR department remained in the original building, the neurology IR

suite relocated to the new pavilion. This transition impacted staffing ratios across all healthcare provider roles. IR personnel underwent training in the new procedure room for several weeks, affecting staffing levels for routine patient care. APPs encountered delays in navigating the new units when consulted to evaluate inpatients for procedures. Furthermore, patient transport staff faced shortages and were tasked with transporting patients across longer distances in unfamiliar corridors. Additionally, the department implemented a new scheduling software, resulting in delays for both inpatient and outpatient procedures. Training sessions for the software conducted during regular work hours inadvertently left room for booking errors to occur, consequently prolonging patient procedure times due to insurance issues, missed scheduling and patient encounters.

Despite these barriers posing challenges to practice flow, several facilitators emerged. The academic hospital's management organized higher staffing ratios through the utilization of travel staff, thereby facilitating smoother operations. This enabled an expanded nursing and radiology staff to care for the scheduled patients, aid in room set up and turn over, and ultimately increased the presence of nurses in the pre-operative area. Buy-ins to this project's goal focused on improved job satisfaction. Improved FCSTs created a cascade of timely procedures, ultimately decreasing patient complaints and dissatisfaction. Moreover, adhering to scheduled procedures alleviated stress among staff members, allowing them to focus more effectively on their tasks without the burden of playing catch-up. Working in this environment with patients who were pleased with their experience in the department promoted a healthy work environment, anecdotally enhancing positive job satisfaction. Collaboration, communication, and staff education were achieved by public displays of FCST metrics and Press Ganey patient satisfaction scores, released monthly by the data experts and customer success managers of Hi-

IQ. Weekly staff discussions and education sessions addressed the importance of FCST success rate, interventions implemented, and concerns of staff.

Discussion

The outcomes of this project implementation differed from expectations in some respects. Outpatients had a higher success rate in starting procedures on time compared to inpatients. Transport and inpatient delays presented more significant challenges than initially anticipated at the project's onset. The opening of the new pavilion added additional stressors to the patient transport staffing ratios and the increased distance for transportation naturally led to longer transportation times for each inpatient. While the presence of an APP did improve timeliness by 5% for outpatient procedure starts, the cost-effectiveness of designating an APP specifically to the pre-operative area, rather than another role, warrants further discussion beyond the scope of this project. Finally, the adjustment of shift times of pre-operative nurses was widely accepted and adhered to, particularly due to the attractive incentive of an earlier end time. Overall, as seen through communication and feedback in weekly staff meetings, the interventions implemented in this 15-week period were generally accepted by the staff and may have contributed to an increase on patient satisfaction and likelihood to recommend scores.

The sustainability of successful first case start times relies on several critical factors. First, strong leadership consistently emphasizing the importance of punctuality and efficiency in starting procedures on time is essential. This involves clear expectations, providing support and resource and holding staff accountable to new interventions. With strong leadership brings the need for continuous feedback mechanisms, which will play a large role in maintaining success. Monthly feedback through Press Ganey scores and FCST metrics will provide ongoing monitoring and evaluation of performance related to start times as well as insights into patient

satisfaction levels based on these efforts. Furthermore, adequate staffing ratios will be fundamental to sustaining successful first case start times. Continuance of sufficient personnel available to support the daily operations of the fast passed, high patient census department will be crucial for maintain efficient workflow and minimize delays. By prioritizing these factors and fostering a culture of efficiency and accountability, the interventions implemented in this project can yield a sustainable environment fostering successful FCSTs.

Within this project, certain factors may have impacted internal validity, including measurement bias, wherein inconsistencies in data collection methods may have occurred. Despite comprehensive training provided to each charge nurse tasked with data collection, the implementation of new scheduling software led to overlooked procedures and adjustments in the day's schedule were made to facilitate staff training in the new pavilion. Missed cases were not recorded so the data used in this study was based on only the data collected. As noted, confounding variables that resulted in patient delays influenced the relationships between the interventions and project goals, potentially resulting in inaccurate data and conclusions as well.

Conclusion

Though the goal of 80% successful FCST was not achieved, the implemented project yielded valuable insights and outcomes. Significant progress was achieved in enhancing the efficiency and timeliness of first case procedures. Despite the challenges faced with workflow changes caused by the opening of a new pavilion and new scheduling software, the project demonstrated resiliency and adaptability. Interventions were still implemented daily despite these challenges. Now, with the settled workflow in the new pavilion and new scheduling system, there is potential for the success rate to further increase. The data collected in this project will certainly prove useful to other interventional radiology departments in other hospital settings

and to other procedural departments who face reduced efficiency, decreased patient satisfaction, and subsequent cascading delays because of delays to their first case procedures. Looking ahead, implementing quality improvement initiatives aimed at mitigating the identified confounding variables could significantly enhance both the quality and efficiency of interventional radiology departments.

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McDermott, O., Antony, J., Bhat, S., Jayaraman, R., Rosa, A., Marolla, G., & Parida, R. (2022, September 21). *Lean six sigma in Healthcare: A systematic literature review on motivations and benefits*. MDPI. Retrieved February 2023, from https://www.mdpi.com/2227-9717/10/10/1910/htm

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Appendix

Table 1 Evidence Review Table

McDermott, O., Antony, J., Bhat, S., Jayaraman, R., Rosa, A., Marolla, G., & Parida, R. (2022, September 21). Lean six sigma in Healthcare: A systematic literature review on motivations and benefits. *MDPI.* Retrieved February 2023, from https://www.mdpi.com/2227-9717/10/10/1910/htm					**Level** I-A
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to understand and identify the evolution, benefits, and motivation of Lean Six Sigma (LSS) in healthcare.	Systematic literature review with meta-analysis	**Sampling Technique:** Systematic **Eligible Participants:** 14,200 articles related to the subject that were published between 2001 and 2021 using academic search engines using key words: "Lean" and "Six Sigma" AND "healthcare", "hospitals", and "health services". **Exclusion:** 14,074 grey literatures (conference papers, books, white papers, etc.), non-English language articles, duplicates, articles not related to the search area or period. **Accepted:** 126 articles or relevant research papers, relating to Lean, Six Sigma, or LSS and their application to healthcare environment and context were in included in this systematic review. **Power analysis:** Not applicable to this systematic review critique	**Control:** Controls varied between studies included in the systematic review (evolution of LSS, motivational factors, and benefits of LSS in healthcare) **Intervention:** Interventions requiring measurement of motivation in using LSS were multi- fold but include reducing medication errors, improving patient safety and treatment. Private organizations differed from public where private motivation interventions included increased competitiveness by acting on cost and profitability and public providers' motivational interventions depended on the challenges related to treatment and national expenses of healthcare.	**Dependent Variable:** Researchers selected articles with the primary focus of understanding the motivational factors of implementing Lean, Six Sigma or Lean Six Sigma in healthcare setting and the benefits of deploying LSS in healthcare. **DV Measure:** motivation was measured in several ways: 1) motivation related to external factors (included need to comply with national health regulations, response to epidemiological changes, achieve sustainability in an environment of reduced funding, etc.) 2) motivation related to organizational issues (including to improve staff and management skills, improve work environment, manage the adoption of new technology, etc.) 3) Motivation related to improving operational performance and profitability (including increased workflow,	**Analysis:** The researchers found in their systematic review that there are various motivational factors for using LSS, but factors differ between public and private health providers. The shared motivator of LSS for each sector, however, was patient safety, ensuring safe treatment and preventing harm or illness. Benefits of implementing LSS in healthcare was seen in all studies to improve operational and financial performance, customer satisfaction, reduced waiting times, reduced medication errors and minimized turnaround times. **Conclusions:** The researchers conclude LSS is a proven operational efficiency methodology in manufacturing, service and now seen in healthcare. This study is intended to help healthcare professionals understand the benefit of LSS in improving operational efficiency and providing

				safety, quality of care and patient satisfaction) Benefits were categorized as real benefits or potential benefits	positive patient, staff, and safety outcomes.
Zepeda-Lugo, C., Tlapa, D., Baez-Lopez, Y., Limon-Romero, J., Perez-Sanchez,3, A., Ontiveros, S., & Tortorella, G. (2020, August 17). *Assessing the Impact of Lean Healthcare on Inpatient Care: A Systematic Review*. National Center for Biotechnology Information. Retrieved February 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7432925/					**Level** I-A
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to evaluate the effects of the methodology, LEAN on healthcare interventions in the inpatient setting and determine if there is an improvement in patient flow and efficiency outcomes.	Systematic literature review using meta-analysis	**Sampling Technique:** Systematic **Eligible Participants:** Systematic Reviews and Meta-Analysis with components of Effective Practice and Organization of Care (EPOC) group's search strategy in combination with selected MeSH terms and free text terms of PICOS elements (population, intervention, comparator, outcome, and study design). **Exclusion:** 1573 studies from their original database searching which included studies with no intervention, no patient flow-related outcome, lack of data, or had different study design. Cross-sectional studies, abstracts and surveys were excluded in the study. **Inclusion:** 39 studies qualified in this study,	**Control:** This systematic review only accepted studies with an inpatient setting, both in private and public health sectors. **Intervention:** The main intervention for this study was the Lean methodology in healthcare, however similar interventions such as six sigma, rapid improvement event (RIE) or Baystate Patient Progress Initiative (BPPI)	**Dependent Variable:** The researchers categorized the outcomes into 2 different groups: 1) utilization of services 2) access to services and resource use **DV Measure:** these outcomes were measured as follows: 1) Utilization of services: measured changes in length of stay (LOS) for admitted patients, changes in on-time starts (OTS) and turnover time (TOT) and turnaround time (TAT) for the perioperative process. 2) Access to service and resource use: measured as boarding time, discharge order time and changes in readmission or re-visit rates. Changes in satisfaction of both patients and staff were secondary outcomes measured. Definitions of these measurement are included by researchers.	**Analysis:** The researchers grouped results into each outcome measurement: **1)** LOS: This most common process-related outcome had varying results between having a reduction (n=9), to reporting no change in LOS (n=3) 2) OTS, TOT and TAT: These measurements were seen most in studies who focused on perioperative workflow. All studies (n=7) with improvements in either OTS, TOT or TAT used multidisciplinary teams during the intervention. 3) Boarding time, early discharge, and readmission: boarding time was reduced in all applicable studies with the longest reduction time of 2.1 hours, resulting in a 5.5hr boarding time. None of the applicable studies (n=9) measuring readmission rates showed an increase after the Lean intervention. Studies either had no change (n=7) or significant reduction (n=2)

		including randomized controlled studies (RCTs), controlled before- after studies, and quasi RCT studies.			**Conclusion:** Lean in conjunction with six sigma methodology, is a stronger approach to improve quality, cost, satisfaction, and speed. Lean focuses on waste reduction and non-value-added activities whereas six sigma focuses on process variation reduction following a define, measure, analyze, improve and control (DMAIC) approach. Using a complementary tool such as six sigma may help an organization focus on leveling patient flow and sold more complex issues.
Tlapa, D., Zepeda-Lugo, C. A., Tortorella, G. L., Baez-Lopez, Y. A., Limon-Romero, J., Alvarado-Iniesta, A., & Rodriguez-Borbon, M. I. (2020, January 23). Effects of lean healthcare on patient flow: A systematic review. *Value in Health.* Retrieved February 2023, from https://www.sciencedirect.com/science/article/pii/S1098301519352179					**Level** I- A
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to assess the effects of Lean healthcare (LH) on patient flow in ambulatory care as well as to determine if there is a reduction in waiting time and length of stay (LOS) after LH is implemented	Systematic literature review of RTCs without meta-analysis	**Sampling Technique:** Systematic **Eligible Participants:** 5,492 studies of healthcare units (clinics, teaching hospitals, general hospitals, specialized hospitals, or health centers) that applied LH interventions in ambulatory care. **Exclusion:** 5,452 studies were excluded due to lack of data, having no intervention, being a different study design, or having an inappropriate	**Control:** Ambulatory care settings in healthcare units such as clinics, teaching hospitals, general hospitals, specialized hospitals, or health centers. **Intervention:** The application of LH and LH-related tools and principles was the primary intervention measured.	**Dependent Variable:** Main outcomes were categorized into two entities: 1) utilization of service or 2) access to service **DV Measures:** The researchers measured utilization of service as the change in LOS (defined as time from arrival to departure) for all patients including LOS for discharged patients (defined as time from arrival to departure for discharged patients) and LOS for admitted patients (defined as time from patients admitted to made inpatient status). Access to service was measured in	**Analysis:** A reduction of LOS was reported in 19 studies, with 142 minutes being the longest reduction recorded, compared to few studies with no change after LH intervention (n=2 studies). Regarding wait time, the time reduced to see a health care professional was seen in 24 studies. Fewer studies examined waiting time to treatment (n=4) and waiting time for appointment (n=2), however each of these studies saw a reduction after intervention as well.

		outcome. Cross-sectional studies, surveys, abstracts, simulations, and opinion articles were excluded. **Inclusion:** 40 Studies published in English or Spanish between January 2002 to December 2018 were included in this study. The researchers included studies of healthcare units (clinics, teaching hospitals, general hospitals, specialized hospitals, or health centers) that applied LH interventions in ambulatory care. The researchers noted this included primary, secondary, tertiary, and quaternary care in private and public health providers.		changes in waiting times (time from door to diagnostic evaluation by a medical professional), wait time for an appointment, and number of patients who left without being seen by a healthcare professional. Secondary measures of these outcomes included patient and staff satisfaction scores (assessed with scales of validated questionnaires)	Interestingly, the researchers found 30 of the 40 studies solely used lean interventions, where 6 were lean six sigma and 4 were lean in combination with other strategies. **Conclusion:** The researchers concluded though most of the reviewed studies reported LH interventions caused shorter LOS and wait times, the combining of lean interventions with other methodologies, such as six sigma, creates greater outcomes than just the sole use of one methodology. Additionally, this study concluded that though reviewed studies suggested healthcare staff perceived LH benefits as an increase in their satisfaction, there was little evidence to assess the benefits LH has on patient satisfaction.
Amaratunga, T., & Dobranowski, J. (2016, May 19). Systematic Review of the Application of Lean and Six Sigma Quality Improvement Methodologies in Radiology. *Journal of the American College of Radiology*. Retrieved February 2023, from https://www.jacr.org/article/S1546-1440(16)30068-0/fulltext					**Level** I- A
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to investigate the effectiveness of applying Lean, Six Sigma or Lean-Six Sigma within the field of radiology	Systematic literature review of RTCs without meta-analysis	**Sampling Technique:** Systematic **Search Strategy**: 278 articles were originally collected from database searches using search terms: Lean, Six Sigma, and	**Control:** This systematic review only accepted studies in an inpatient or outpatient-based radiology department setting including MRI, CT< radiography, mammography, bone densitometry, interventional radiology,	**Dependent Variable:** The following outcomes were measured among the accepted studies: 1) Appointment wait times 2) In-department wait times 3) Patient volume 4) Cost savings 5) Cycle Time 6) Defects 7) Staff and patient	**Analysis:** The researchers found that for Lean, Six Sigma and Lean-Six Sigma studies, high quality randomized or time-series design are the ideal selection due to their methodologic strength. The researchers also note that if

		Lean Six Sigma. Two subsets of terms were combined using the Boolean operator AND to procure results. Two reviewers screened collected data. **Exclusion:** 255 were excluded based on lack of intervention, different methodology or outcomes, poorly described literature, and non-clinical setting **Inclusion:** 19 studies met inclusion criteria by the researchers and an additional 4 articles were identified from a secondary search after inclusion criteria was applied. The researchers exclusively included articles conducted in a radiology context with an implementation of either Lean, Six Sigma or Lean-Six sigma to improve quality and/or process of care.	administrative radiology, and orthopedic radiology. **Intervention:** The primary intervention studied in this synthesis was the application of the methodology Lean to a radiology department. Other similar interventions, such as Six Sigma and Lean- Six Sigma were studied as well.	safety and satisfaction. Each of the outcomes were defined clearly in the study. **DV Measures:** 1) Appointment wait times were measured as the time elapsed between the day the consult for an exam was made and the day the exam occurred. 2)In department wait times were measured as the length of time a patient waited from their arrival to the department to the time of their procedure preparation 3) Patient volume was measured by the increase in exams performed in a single setting 4) Cost savings was measured as both a gross cost reduction against a department or an increase in revenue due to increasing exam quantity 5)Cycle time was measured as the amount of time spent preforming an exam 6) Defects was measured as the amount of unnecessary repeated procedures 7)Staff and patient safety and satisfaction was measured through standardized survey scores for both patients and staff. Quality assessment of each result was performed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) recommendations.	this is such, future investigators must be thorough in that each metric has full cycles of adequate representation in frequency and duration of data collection. **Conclusion:** Lean and Six Sigma are successful methodologies used to improve workflow and several quality metrics.

Nicolay, C. R., Darzi, A., Purkayastha, S., Greenhalgh, A., Benn, J., Chaturvedi, S., & Phillips, N. (2021, November 11). Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. *Academic.oup.com.* Retrieved February 2023, from https://academic.oup.com/bjs/article/99/3/324/6138712?login=false					**Level** V-B
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to identify and evaluate the application and effectiveness of quality improvement methodologies from the manufacturing industry in the field of surgery.	Systematic literature review of RTCs without meta-analysis	**Sampling Technique:** Systematic **Search Strategy** A search was conducted using the Preferred Reporting Items for Systematic review and Meta analyses (PRISMA) statement. Search terms were organized to cover surgical healthcare and the names of several quality improvement methodologies 1595 studies were initially identified and then screened and eliminated based on exclusion and inclusion criteria, which are documented. Eligibility was decided independently in a standard manner by two reviewers.	**Control:** Varied between studies included this systematic review. Quality improvement methodologies included: plan-do-check-act (PDCA) or plan-do-study-act (PDSA) cycles, statistical process control (SPC) or statistical quality control (SQC), continuous quality improvement (CQI), total quality management (TQM), Six Sigma, Lean and Lean Six Sigma) **Intervention:** The application of various QI methodologies to evaluate their effectiveness in surgical departments.	**Dependent Variable:** Variation in interventions were seen in the application of QI methodologies to surgical patient care which included: infection control, reducing complications/improving outcomes, reducing delays, antibiotic use, and length of stay **DV Measure:** Infection measured and defined as number of catheters associated blood stream infections, methicillin-resistant *Staphylococcus aureus* infections and surgical site infections Reducing complications/improving outcomes was defined and measured as rate of 30-day mortality rates and rates of returns to the operating room due to surgical complications	**Analysis:** The researchers noted limitations with their synthesis: there was a small selection of studies that met the inclusion criteria. The literature consisted of more observations rather than statistical analysis. The study only included one RCT, which leaves to conclude there is a large element of bias in the results. **Conclusion:** QI methodologies produce significant effects on improving workflow and care in surgical departments. However, with a lack of RCTs it is difficult to make definitive conclusions about QI methodologies effectiveness.

		Disagreements between reviewers were resolved by consensus. **Exclusion:** Studies were excluded if 1.) the article was an abstract, editorial, letter, opinion, audit or review 2.) if the population studied was non-surgical 3) the article did not provide outcome data **Inclusion:** 34 studies met the inclusion criteria with the aim to 1) reduce complications or improve outcomes 2) reduce infection 3) reduce delays 4) improve antibiotic usage 5) reduce pain 6) reduce length of hospital stay and 7) reduce cost		Reducing delays was measured and defined as rate of start of surgery delays, Antibiotic use was measured and defined as the rate and appropriateness of using presurgical antibiotics Length of Stay was defined and measured as duration of time stayed in the hospital post-surgery.	

Cox Bauer, C. M., Greer , D. M., Vander Wyst, K. B., & Kamelle, S. A. (2016, August 8). First-Case Operating Room Delays: Patterns Across Urban Hospitals of a Single Health Care System. Retrieved February 2023, from https://institutionalrepository.aah.org/cgi/viewcontent.cgi?article=1265&context=jpcrr					**Level** III-A
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this study was to determine if on-time start for first surgical cases differed by hospital facility and identify existing patterns of start delays in three urban hospitals operating rooms within	Retrospective Cohort Study	**Sampling technique:** Convenience **Search Strategy:** All patients aged ≥ 18 years who underwent first-case-of-the-day surgeries at three hospitals from July	**Control:** Patients scheduled as first surgical case start among each of the three urban hospitals operating rooms. **Intervention** Many factors were examined as to why a patient may be late to	**Dependent Variable:** On-time start was defined by the national standard as the in-room time equal to or before scheduled surgical time. **DV Measures:** To examine the flow of patients from arrival to procedure time four events were	**Analysis** Across the three urban hospitals of the same large health care system, the researchers found over 88% of first-of-the-day nonemergency surgeries were delayed. On average, patients in this health care system waited 24

the same health care system.		2012 through November 2013. **Exclusion:** Pediatric patients, age <18 years old and patients scheduled as subsequent procedures from the first scheduled. **Inclusion:** 5,598 total first-of-the day surgeries between the three hospitals of adult patients ≥ 18 years old.	entering the procedure room, some factors were fixed, such as patient age, sex, race/ethnicity, body mass index, while influencing variables with a binary response of surgical case delay (yes or no) included: presurgery overnight hospital stay (yes or no), late patient arrival (<2 hours early) to the hospital (yes or no), number of planned procedures during surgery, maximum years of surgical experience among participating surgeons, surgical service provided and hospital facility.	evaluated to measure the patient's progression toward entering the procedure room: patient arrival at the hospital, placement of patient in the OR, start of anesthesia, and start of procedure.	minutes beyond scheduled surgery time to be placed in the OR and nearly 1 hour for procedure start. Across hospitals, the most documented reasons for delay were the physician, anesthesia, and patient. 65% of patients arrived late, increasing their odds of a late surgical start by 35%. Additionally, the patient's odds of experiencing late in room placement increased with their age. **Conclusion** The researchers found significant delays in first of-the-day surgical cases, in terms of both frequency and duration, at all three facilities. They conclude that the reduction of delays will require increased patient adherence to recommended arrival times, more complete documentation of delays by medical staff and greater consistency in methods of documentation and workflow patterns among facilities and departments.
Antony, J., Palsuk, P., Gupta, S., Mishra, D., & Barach, P. (2018, May 8). Six sigma in Healthcare: A systematic review of the literature. *International Journal of Quality & Reliability Management.* Retrieved February 2023, from https://www.emerald.com/insight/content/doi/10.1108/IJQRM-02-2017-0027/full/html					**Level I-B**
Purpose/ Hypothesis	**Design**	**Sample (population, size, setting)**	**Intervention**	**Outcomes/ Measures**	**Results Conclusions**
The purpose of this systematic review was to evaluate the incorporation of six	Systematic literature review of RTCs without meta- analysis	**Sampling technique:** Systematic **Search strategy**	**Control:** The application of the methodology Six Sigma among five categorized	**Dependent Variable:** Variables ranged from three measured categories: benefits of Six Sigma implementation, tools	**Analysis:** 68 research papers drawn from 31 refereed journals were primarily driven from the continents North

sigma interventions in the healthcare setting aimed to improve patient outcomes		1623 English-language studies published between 1998 and 2016, using the academic databases Web of Science, Medline, Emerald Insight, ASQ and ProQuest were identified with the following key search words: "Six Sigma" AND "Health" OR "Healthcare". **Exclusion:** Grey literature (conference papers, magazine related articles, workshops, books, editorials, prefaces, poster sessions, panel discussions and commentaries) were excluded in this systematic review, as well as studies that focused exclusively on Lean Thinking and Lean Six Sigma. Research on quality management, Continuous Improvement (CI) related papers were also excluded as well as studies that weren't published in peer-	healthcare settings: general (represents the literature which does not specify the area of application and the hospital group has been derived from studies which consider the entire hospital as a sample unit), hospital, clinical specialties, diagnostic services, and other services. **Intervention:** The incorporation and utilization of Six Sigma interventions on a healthcare setting aimed to improve patient outcomes.	used in the Six Sigma implementation, and adoption challenges faced. **DV Measure:** Benefits were categorized into five perspectives based on major stakeholders including customer or patient focus, financial improvement, operation excellence, people, and compliance. The top 5 benefits measures included patient satisfaction, process speed (reduction of process cycle time), revenue enhancement, cost savings, and defect reduction Tools were defined as Six Sigma tools used in the DMAIC (Define-Measure-Analyze-Improve-Control) roadmap. Challenges was defined and grouped as studies identifying barriers to implementation or improving patient outcomes and were grouped as Six Sigma related challenges, project implementation challenges, people related challenges, post-implementation, and other challenges	America (38), Europe (20) and Asia (10). Within these continents, USA (37), UK (5) and India (4) are the leading countries in literature supporting Six Sigma implementation directed towards improving patient outcomes in a healthcare setting. It is important to note that most of these studies (~49%) have been developed to analyze the relevance of Six Sigma application within an entire hospital rather than a particular unit or function. **Conclusion:** The researchers conclude that the most common benefits of Six Sigma implementation in healthcare are improvement in patient safety, improvement in process speed (i.e., increased productivity) and revenue enhancement The most commonly used Six Sigma tools analyzed included data collection planning and strategy, monitoring and control plan, implementation plan, brainstorming and root cause analysis. With the challenges measured and analyzed in the use of Six Sigma within healthcare services, the availability of data is the most prominent

		reviewed journals were also excluded. **Inclusion:** 68 high quality journals and articles from specialized healthcare journals which solely discussed Six Sigma implementation and practice focusing on healthcare services were included.			challenge for Six Sigma implementation.

Table 2. Evidence Synthesis Table

Project Title: **Improving First Case Start Times in Interventional Radiology**			
JHNEBP Model Level	**Total Number of Sources**	**Author and Quality Rating of each study**	**Synthesis of Findings**
Level 1 Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis	5	McDermott, et al., 2021 A Zepeda-Lugo, et al., 2020 A Tlapa, et al., 2020 A Amaratunga & Dobranowski, 2016 A Antony, et al., 2018 B	Methodologies such as Six Sigma or Lean Six Sigma are proven operational efficiency methodologies in manufacturing, service and now seen in healthcare. The conjunction of the two methodologies provides a stronger approach to improve quality, cost, satisfaction, length of stays and wait times. Lean focuses on waste reduction and non-value-added activities whereas six sigma focuses on process variation reduction following a define, measure, analyze, improve and control (DMAIC) approach. Using a complementary tool such as six sigma may help an organization focus on leveling patient flow and sold more complex issues. Six Sigma tools used most frequently used among healthcare settings included a multidisciplinary approach to data collection planning and strategy, monitoring and control plan, implementation plan, brainstorming and root cause analysis.
Level II Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis			
Level III Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies with or without meta-synthesis	1	Cox Bauer, et al., 2016 A	In retrospective cohort study, significant delays of the first case procedural start in all procedural departments were seen across a major urban health care system. Delays were seen in both frequency of procedures and duration of procedures. The reduction of delays will require increased patient adherence to recommended arrival times, more complete documentation of delays by medical staff and greater consistency in methods of documentation and workflow patterns among facilities and

			departments.
Level IV Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence			
Level V Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence	1	Nicolay, et al., 2021 B	QI methodologies produce significant effects on improving workflow and care in surgical departments. However, with a lack of RCTs it is difficult to make definitive conclusions about QI methodologies effectiveness.
Overall Quality Rating w/rational and Recommendation: Based on Evidence Synthesis: A; Strong evidence supports not only supports first case start times have a direct and powerful impact on numerous patients impacting variables including length of stay, patient satisfaction, quality of life, and financial but also this evidence provides insight that the methodology, Lean and Six Sigma have a strong impact in improving these variables. It is recommended to implement Lean Six Sigma in a procedural department in order to improve first case start times and therefore improve patient satisfaction.			

Appendix A

RedCap First Case Start Time Success Rate Tool

First Case Start Time Success Rate Tool

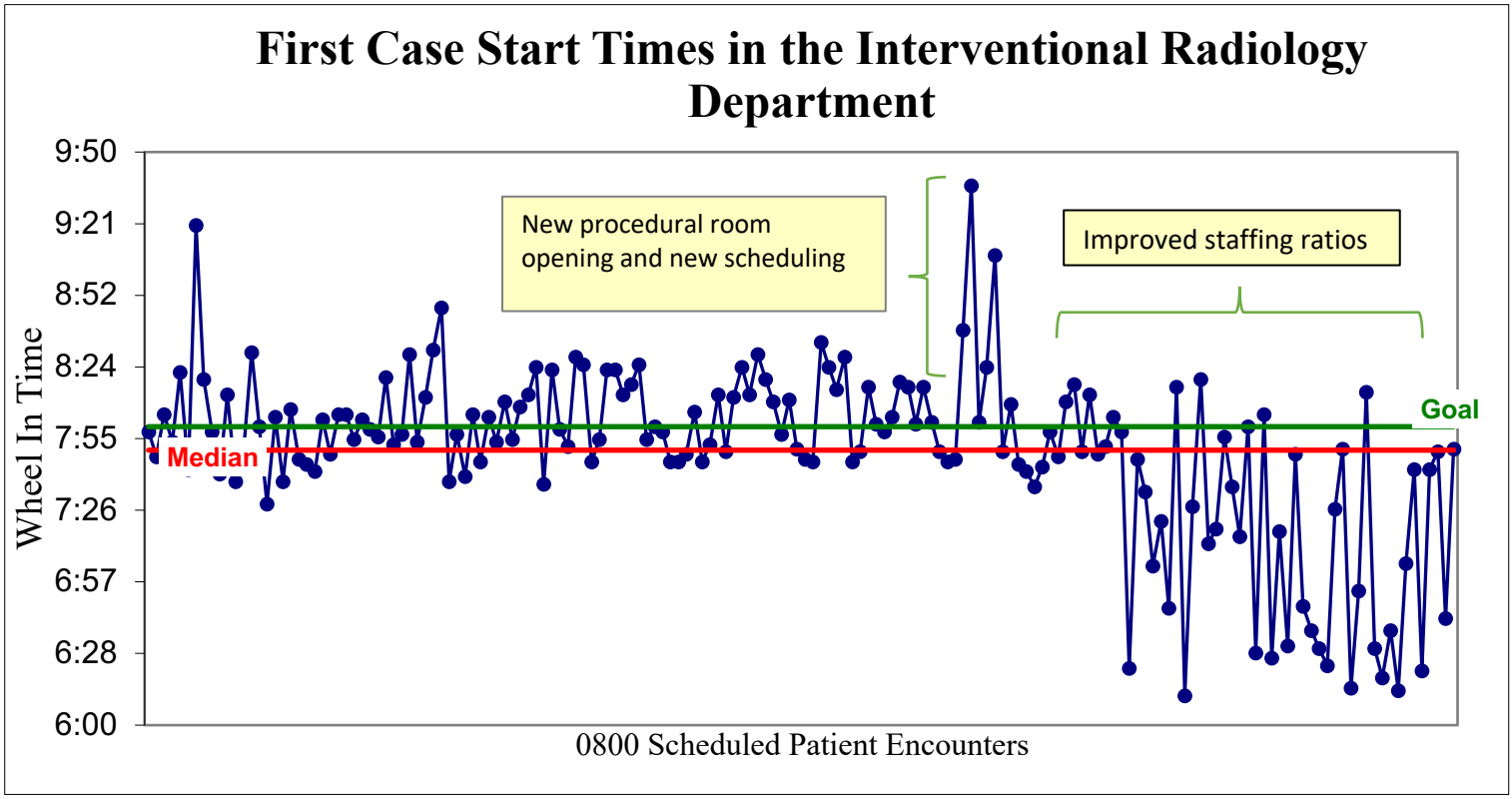
Please complete the survey below.

Thank you!

1)	Date	_____
2)	Did the Pre-Op Nurse and Charge arrive at 0630?	◯ Yes ◯ No
3)	Pre-procedure instructions to patient	☐ Arrive at 0630 and confirmed with patient/ family member ☐ Left voicemail ☐ Unable to contact patient at all ☐ Inpatient
4)	Type of patient	◯ Inpatient ◯ Outpatient ◯ Emergency
5)	Patient Arrival to Department Time	_____
6)	Transport delay? (>15 minutes)	◯ Yes ◯ No
7)	Patient have difficult mobility?	◯ Yes ◯ No
8)	Difficult IV access?	◯ Yes ◯ No
9)	Is there a designated attending and APP to see patient in Pre-Op?	◯ Yes ◯ No
10)	Anesthesia Case?	◯ Yes ◯ No
11)	Time patient is "wheels- in" to procedure room	_____
12)	Was this procedure a G/ GJ/ J tube placement, replacement, exchange?	◯ Yes ◯ No
13)	If yes to the above question, was the tube verified upon scheduling?	◯ Yes ◯ No
14)	Was this patient canceled due to unavailable equipment?	◯ Yes ◯ No
15)	Reason for delay	☐ Nursing delay ☐ Attending delay ☐ APP/consenting delay ☐ Anesthesia Delay ☐ Procedural room prepardness delay ☐ other
16)	If reason for delay was other, please explain why	_____

Figure 1

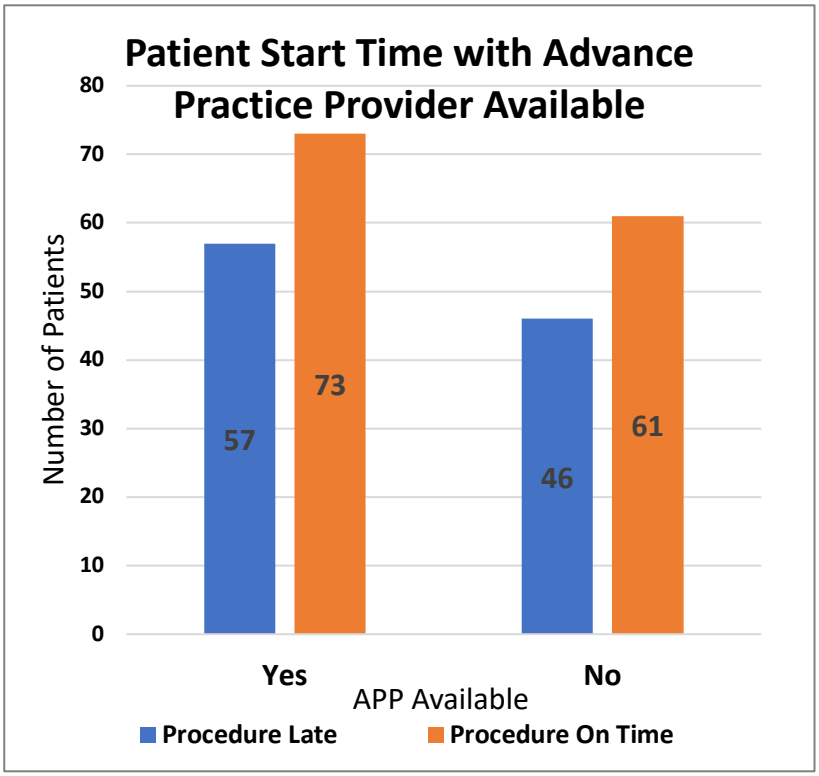
Run Chart of First Case Start Times in Interventional Radiology



Note. There is a shift in this run chart above and below the median line which requires further investigation as to what caused these data points to be significant. See Appendix C, D, and E for further data showing various interventions' relationship to on-time procedure starts.

Figure 2

Effects of Advance Practice Provider presence and Procedure Start



Note. Though there was an increased rate of on time procedures when an APP was present.

Figure 3

On Time Versus Late Procedure Start Times

Figure 4

Inpatient Versus Outpatient and Procedure Start Times

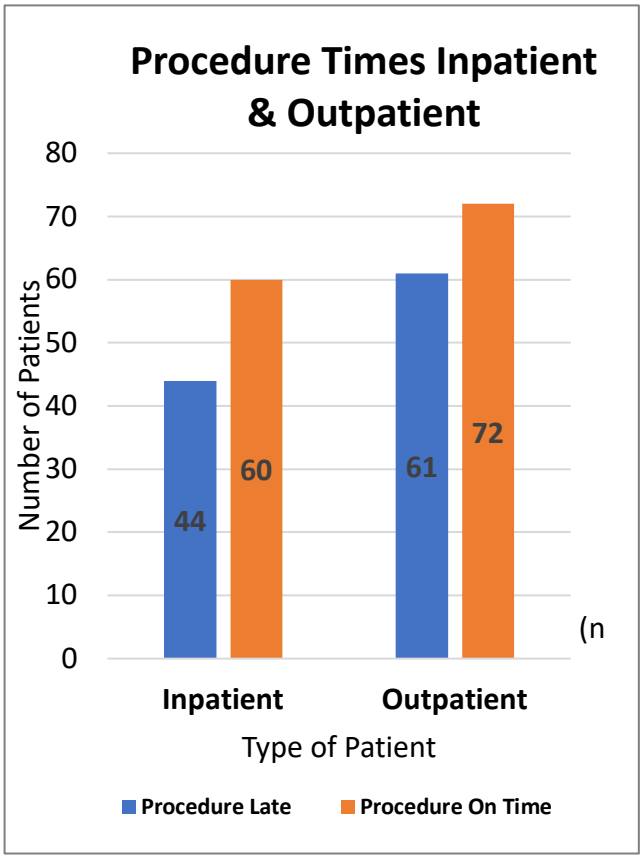


Figure 5
Press Ganey Scores of 2023