Proceedings of the Annual General Donald R. Keith Memorial Conference
West Point, New York, USA
April 24, 2025
A Regional Conference of the Society for Industrial and Systems Engineering

Optimizing the Orthopedic Service Line at UHS Chenango Memorial Hospital: A Process Improvement Initiative

Christina Bergen[1], Margaret Doyle[1], Amaya McCollough[1], Amyra Zheng[1], and Srikanth Poranki[1,2]

[1]Systems Science & Industrial Engineering Department, Binghamton University, Vestal, NY 13905

[2]UHS Chenango Memorial Hospital, Norwich, NY 13815

Corresponding Author's Email: christinabergen03@gmail.com

Author Note: Christina Bergen, Margaret Doyle, Amaya McCollough, and Amyra Zheng are seniors at the State University of New York at Binghamton. Special gratitude is extended to our project advisor, Dr. Srikanth Poranki, for his guidance and support throughout the project. We also thank our project sponsors, Dace Dinney, Chris Kisacky, and Dr. Thomas Genes from UHS Chenango Memorial Hospital, as well as the UHS CMH staff for providing necessary resources, including data, insights, and feedback, that allowed our project to move forward.

Abstract: This paper presents a systems engineering approach to optimize healthcare delivery in the orthopedic service line at UHS Chenango Memorial Hospital, a small community-based hospital serving a rural population in South-Central New York. The challenges of delivering effective & efficient surgical care in rural settings are compounded by lack of appropriate resources, inefficient processes, particularly in preoperative preparation and insurance authorization workflows. Analysis of patient timelines revealed an average of 166 days from initial consultation to surgery completion, significantly exceeding industry benchmarks. Process mapping identified key bottlenecks in pre-admission testing coordination and surgery authorization. The resulting solution framework includes streamlined preoperative testing protocols aligned with American Society of Anesthesiologists guidelines, standardized patient journey pathways, and optimized surgery authorization processes. This paper discusses the methodology used to develop these solutions, quantifies the expected operational impacts, and outlines implementation strategies designed to enhance both patient experience and staff efficiency while improving resource utilization in a resource-constrained rural healthcare setting.

Keywords: Healthcare Process Improvement, Rural Healthcare Access, Patient Flow Optimization, Preoperative Process Standardization

1. Introduction

Rural communities face significant healthcare access challenges, particularly for specialized services such as orthopedic surgery. These challenges encompass health disparities, system barriers, and infrastructural gaps that prevent timely care delivery. UHS Chenango Memorial Hospital (CMH), a 58-bed short-term acute care community hospital located in Norwich, NY, serves a rural region in South-Central New York characterized by limited transportation options, economic insecurity, and higher-than-average rates of chronic disease. Operational inefficiencies in healthcare settings have been documented to significantly impact both patient care and organizational effectiveness. Tucker (2004) found that "operational failures interrupted nurses' concentration, delayed patient care, wasted hospital resources and put patients at risk." For rural hospitals like CMH, these inefficiencies are particularly problematic as they further limit already constrained access to specialized care. The orthopedic service line at CMH faces challenges including redundant testing procedures, extended insurance authorization timelines, and communication gaps between departments. These issues have resulted in extended patient wait times, higher same-day cancellation rates, and resource overutilization. Specifically, redundant Pre-Admission Testing (PAT) and communication gaps directly contribute to extended authorization timelines, as insurance companies often require complete and current test results before approving surgical procedures. While the average industry benchmark for orthopedic surgery timelines is approximately 90 days from consultation to procedure (Centers for Medicare & Medicaid Services, 2021), analysis of CMH data revealed an average of 166 days, with significant variability (standard deviation of 143 days).

This paper examines a comprehensive process improvement initiative designed to optimize the orthopedic service line workflow, with particular focus on streamlining pre-surgical processes to enhance accessibility and ensure timely surgical care for rural patients.

2. Problem Definition

2.1 Current Process Challenges

Analysis of 40 elective orthopedic cases performed at CMH revealed significant variability in patient timelines and process efficiency. Of these cases, 32 resulted in completed surgeries with patient timelines ranging from 4 to 454 days. For this study, patient timeline is defined as the period from initial orthopedic consultation to the date of surgery completion or cancellation. "Completed surgeries" refer to procedures that were successfully performed, while "incomplete surgeries" refer to cases where the procedure was canceled or never performed due to various factors including insurance denials, patient decisions, or clinical contraindications. Quantitative analysis of patient records and qualitative assessment through structured stakeholder interviews (Bergen et al., 2024) identified three primary areas of concern:

1. **Patient Experience Challenges:** Extended wait times between clinical visits prolonged patient discomfort and functional limitations. Communication gaps and process variations require patients to navigate complex healthcare systems with limited guidance, creating trust issues and potential financial uncertainties. Patient satisfaction survey data collected through the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) revealed consistently low scores (in the 1-49 percentile range globally) for questions related to pre-procedure information and nurse communication during preparation.
2. **Staff Efficiency Constraints:** Manual scheduling processes conducted without system-level visibility created risks of double-booking, information loss, and scheduling conflicts. The lack of real-time updates and standardized communication protocols led to inefficient resource allocation and coordination difficulties between departments.
3. **Financial Implications:** High insurance denial rates and resource overutilization that ultimately result in revenue loss and increased administrative costs. Process inefficiencies led to unnecessary spending and lost reimbursement opportunities, threatening the financial sustainability of specialized services in this rural setting.

Analysis revealed significant variability in patient wait times, with substantial differences between completed and incomplete surgical cases. Patient timelines ranged from just 4 days to as long as 454 days, with incomplete surgeries showing a higher median duration (133 days) compared to completed surgeries (median 113 days). This distribution highlights a critical insight: patients remaining in the pre-surgical process (defined as the sequence of steps from initial consultation through pre-admission testing and insurance authorization) for extended periods face an increased risk of their surgery being canceled or never scheduled. Statistical analysis revealed a positive correlation ($r=0.67$, $p<0.05$) between extended timelines and same-day surgical cancellations, underscoring the urgency of streamlining the pre-operative process to improve completion rates. The data demonstrates that the likelihood of a case resulting in an incomplete surgery increases by approximately 25% when the timeline exceeds 300 days, compared to cases resolved within 90 days.

2.2 Process Flow Analysis

Comprehensive process maps depicting the orthopedic patient journey were developed from initial diagnosis through 30-day post-operative follow-up. Through structured process mapping sessions with key stakeholders, each step in the patient journey was visually represented, identifying handoff points, decision nodes, and potential bottlenecks. This visual representation revealed critical bottlenecks primarily concentrated in pre-operative phases, particularly during insurance authorization for orthopedic consultation and during the surgical authorization process.

To comprehensively understand the current workflow, we mapped the entire orthopedic patient journey from initial referral through 30-day post-operative follow-up; a high-level process map can be found below in Figure 1. This process map uses color-coding to highlight bottleneck areas, particularly in the surgery authorization and pre-admission testing phases. Visual documentation of all steps, decision points, and handoffs provided critical insights into complex points that contribute to extended patient timelines. The mapping exercise revealed numerous redundant steps and unclear responsibility transitions that remained undetected when examining departmental processes in isolation.

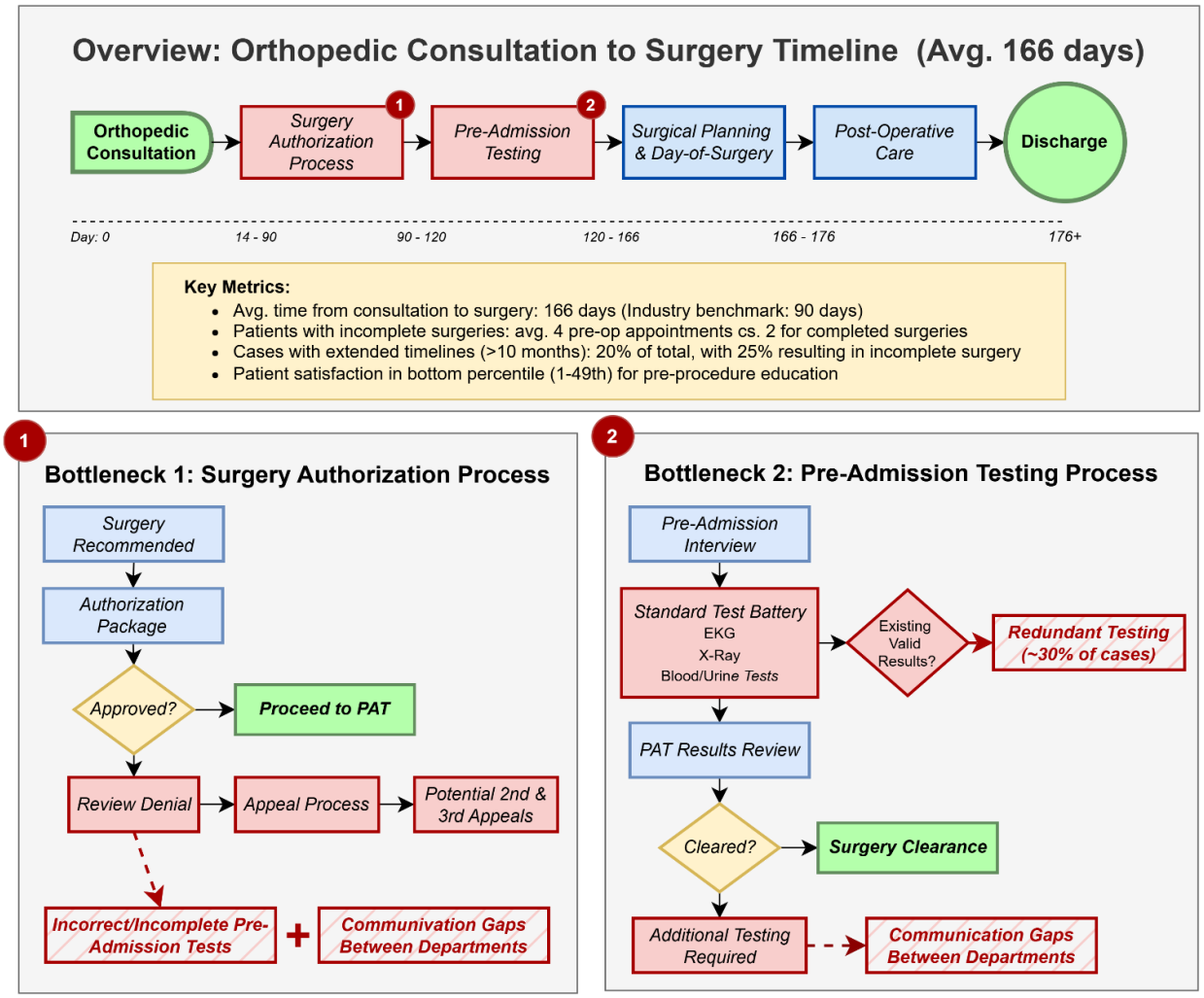

Figure 1. High-Level Process Map of UHS Chenango Memorial Hospital Orthopedic Service Line

The surgical authorization process was identified as especially problematic, requiring extensive documentation packages including imaging results, pre-admission test results, and supporting clinical documentation. This authorization phase frequently triggered multi-level appeals when initial requests were denied, substantially extending patient wait times and creating significant administrative burden.

Additionally, the Pre-Admission Testing (PAT) workflow lacked standardized protocols for identifying existing valid test results, leading to redundant diagnostic procedures that increased costs and patient inconvenience without improving surgical outcomes. The data analysis revealed that patients with uncompleted surgeries underwent an average of 4 pre-operative appointments, compared to just 2 for those with completed surgeries, highlighting the inefficiency in the current process.

3. Gap Analysis & Improvement Methodology

3.1 Industry Standard & Gap Analysis

Comparison of CMH's current processes with industry standards revealed significant opportunities for improvement. Joint Commission standards (Joint Commission, 2023) emphasize streamlined pre-surgical processes that minimize unnecessary testing while maintaining patient safety. Similarly, American Society of Anesthesiologists guidelines (ASA, 2023) recommend targeted preoperative testing based on individual risk factors rather than routine universal testing. CMH's current practice of standardized testing for all patients contradicts these evidence-based recommendations. Centers for Medicare & Medicaid Services guidelines (CMS, 2021) suggest that elective orthopedic procedures should typically progress from initial

consultation to surgery within 90 days. CMH's average timeline of 166 days and multiple outlier cases of timelines exceeding 300 days (10 months), indicate substantial operational inefficiencies requiring systematic intervention. Best practices in orthopedic care coordination, as outlined by the American Academy of Orthopedic Surgeons (AAOS, 2022), emphasize clear communication channels between referring providers, specialists, and support services. The communication gaps identified at CMH represent a critical deviation from these standards, contributing to fragmented care experiences reflected in low patient satisfaction scores.

A root cause analysis using an Ishikawa (Fishbone) methodology (Ishikawa, 1990), shown in Figure 2, identified the underlying causes of these inefficiencies. This structured approach categorized contributing factors across six key areas: patient communication, departmental communication, information systems, process standardization, testing procedures, and workflow management. The analysis revealed that no single factor was responsible for the extended timelines; rather, the issues stemmed from a combination of siloed departments, poor hand-offs between teams, outdated information systems, and inconsistent protocols. This comprehensive view was essential for developing solutions that addressed the interconnected nature of the problems rather than implementing isolated fixes.

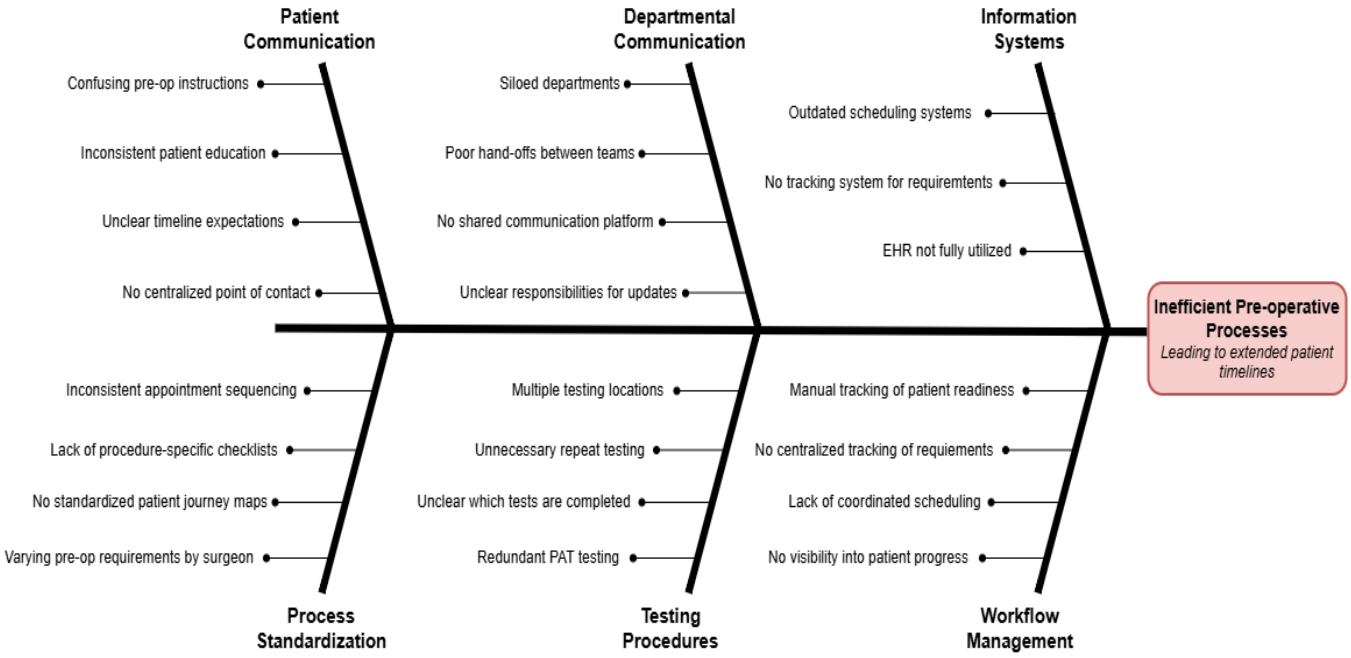

Figure 2. Ishikawa Diagram of Failure Points Resulting in Extended Patient Timelines

3.2 Improvement Targets

A Critical-to-Quality (CTQ) tree (Sholtes et al., 2018), shown in Figure 3, was developed based on comprehensive analysis that translates the identified needs into specific, measurable improvement targets. This engineering approach connects the core need—optimizing inefficient pre-operative processes to reduce patient timelines—to three key requirements: Streamlined Communication Streams, Standardized Patient Journeys, and Streamlined PAT Processes. Each requirement includes concrete performance metrics, including achieving 80% patient satisfaction in communication categories and reducing outlier cases with extended timelines by 50%. This structured framework ensures interventions directly address root causes and can be objectively evaluated.

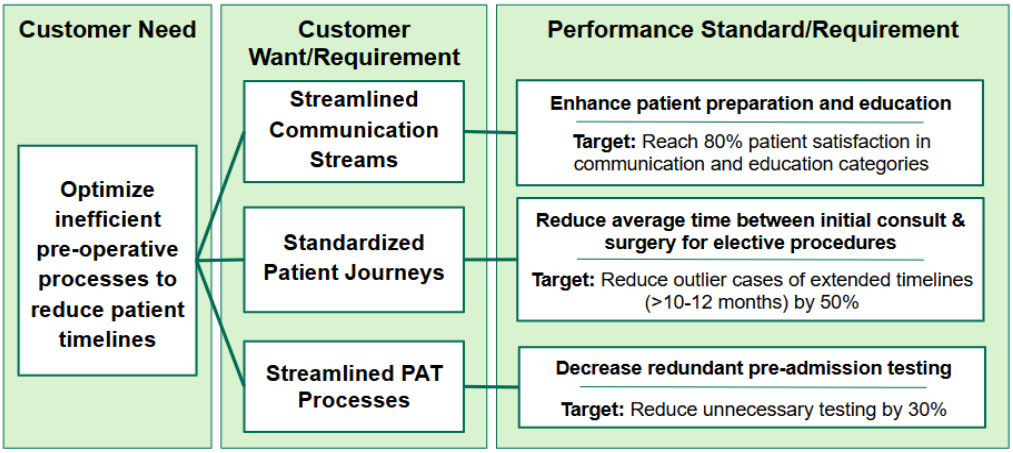

Figure 3. Critical-to-Quality Diagram of Project Objectives and Target Metrics

This approach employed multiple industrial engineering and quality improvement methodologies. Ishikawa analysis helped identify root causes across six categories: patient communication, departmental communication, information systems, process standardization, testing procedures, and workflow management. This structured approach revealed that inefficient pre-operative processes were caused by a combination of siloed departments, poor hand-offs between teams, outdated scheduling systems, inconsistent appointment sequencing, and redundant testing, all leading to extended patient timelines.

4. Implementation Framework

4.1 Patient Journey Standardization

As a central component of the solution, standardized orthopedic procedure journey maps reimagine the orthopedic workflow of different elective procedures offered at CMH on both the patient and staff end. Standardization of these procedures aims to eliminate unnecessary steps while adding critical communication touchpoints and clear responsibility transitions. The maps will define estimated timeframes between milestones and identify accountable parties for each transition, addressing the variability that characterized the current process. By comparing this optimized journey with the current state map, stakeholders can visualize how the proposed changes will streamline operations and significantly reduce opportunities for delays and miscommunication.

This standardization will also extend to patient history reviewing to ensure that the PAT staff at CMH can avoid unnecessary ordering of tests when existing, usable results are available. Creating checklists regarding points of cross-checking and inter-departmental communication can significantly decrease the likelihood of redundant testing and mitigate unnecessary costs for both the patient and hospital.

Analysis of surgical cases by patient timeline ranges revealed that cases extending beyond 300 days had a 25% incompletion rate, compared to 15-22% for shorter timelines. This standardization is expected to reduce the standard deviation in patient timelines by 30-40%, creating more predictable care experience and improving resource utilization across departments.

4.2 Communication Enhancement Strategy

Based on the low patient satisfaction scores related to communication (consistently in the bottom percentile for questions regarding pre-procedure information and preparation), a structured communication improvement framework centralizes communication between departments and standardizes patient education materials. Through these interventions, we can ensure that patients are knowledgeable about their surgical journey and staff are equipped with the proper resources to provide their patients with satisfactory care and education. In doing so, we hope to improve patient satisfaction scores by 5-10% within the first year of implementation.

5. Conclusion

The process improvement framework presented in this paper illustrates how systems engineering principles can effectively address healthcare delivery challenges in resource-constrained rural settings. The CMH orthopedic service line case study demonstrates the value of industrial engineering methodologies in identifying and resolving operational inefficiencies that impact patient care.

Process mapping visualization revealed critical bottlenecks in pre-operative phases that would have remained invisible when examining departmental processes in isolation. The Ishikawa diagram methodology categorized contributing factors across six key domains, providing a comprehensive understanding of how system elements interact to create inefficiencies. Additionally, the Critical-to-Quality tree approach translated identified needs into specific, measurable improvement targets directly connected to patient-centered outcomes.

These engineering methodologies provide healthcare administrators with data-driven insights to inform strategic decision-making about resource allocation and process redesign. The systematic approach to problem identification and solution development offers a template applicable to other service lines or healthcare facilities facing similar operational challenges, demonstrating how systems engineering principles can improve healthcare delivery in resource-constrained environments.

5.1 Limitations and Future Work

This study illustrates the application of engineering tools in healthcare with limitations focused on process efficiency rather than comprehensive patient experience. Implementation success depends on organizational factors including staff adoption and change management. Future research should expand these methodologies to incorporate clinical effectiveness and patient-centered outcomes, explore adaptations for varied healthcare settings, and integrate with established frameworks like Lean Healthcare or Institute for Healthcare Improvement models.

In conclusion, this work demonstrates how industrial engineering methodologies can address operational inefficiencies in healthcare settings. Systematic analysis techniques enhance both effectiveness and resource utilization while improving access to essential services. The CMH orthopedic service line example illustrates the practical application of these approaches in healthcare delivery systems.

6. References

American Academy of Orthopedic Surgeons. (2022). Patient-Centered Care for Orthopedic Surgery. AAOS Clinical Practice Guidelines. Retrieved 2025, from https://www.aaos.org/quality/patient-centered-care/

Avinash Maganty, M. E. (2023). *Barriers to rural health care from the provider perspective.* Rural Remote Health. doi:10.22605/RRH7769

Bergen, C., Doyle, M., McCollough, A., & Zheng, A. (2024) Stakeholder interview protocol and findings for orthopedic process improvement at UHS Chenango Memorial Hospital. Unpublished raw data.

Centers for Medicare & Medicaid Services. (2021). Quality measures and performance standards for orthopedic procedures. Retrieved 2025, from https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/HVBP/Hospital-Value-Based-Purchasing

Ishikawa, K. (1990). Introduction to Quality Control (J.H. Loftus, Trans.). Productivity Press

Joint Commission. (2023) Comprehensive Accreditation Manual for Hospitals. Standards for Pre-Surgical Processes. Oak Brook, IL: Joint Commission Resources

Prengaman, M. V. (2016). *A case study of individual and organizational stakeholder perspectives on state factors impacting access to rural health care services in Idaho.* Albuquerque: The University of New Mexico. Retrieved 2025, from https://digitalrepository.unm.edu/nurs_etds/34/

Routine Preoperative Testing: Comparative Effectiveness Review. Agency for Healthcare Research and Quality (2013). Retrieved 2025, from https://effectivehealthcare.ahrq.gov/products/preoperative-testing/research-protocol

Scholtes, P., Joiner, B., & Streibel, B. (2018). The Team Handbook: How to Use Teams to Improve Quality (3rd ed.). Oriel Inc.

Sutton, I. (2022). *2022-2024 Community Health Assessment/Community Health Needs Assessment and Community Health Improvement Plan/Community Service Plan.* Norwich, NY: Chenango County Department of Public Health.

Tucker, A. L. (2004). The impact of operational failures on hospital nurses and their patients. *Journal of Operations Management, 22*(2), 18. Retrieved 2025

UHS Chenango Memorial Hospital Quality Department. (2025). Patient satisfaction survey data for orthopedic service line, 2024-2025. Internal report. Norwich, NY: UHS Chenango Memorial Hospital