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Case Study

Digital patient engagement at a perioperative surgical home implemented community hospital

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Abstract

Patients in rural areas typically require more perioperative 'optimization' for surgery. The rural healthcare systems often overwhelmed with coordinating perioperative services and deliver less than optimal surgical outcomes. This is due to limited supporting microsystems and ability to effectively engage and track patients over the 120-day perioperative period to limit post-surgical complications. The study assessed longitudinal patient engagement within a newly established Perioperative Surgical Home (PSH) at a rural community hospital serving 10+ surrounding counties to identify barriers and best practices for engagement. A digital patient engagement platform was implemented and used to assess longitudinal patient outcomes and engagement from 30 days preoperative to 90 days postoperative. The research team (health systems engineers teamed with clinicians) analyzed 2-years of collected patient data (n= 301) primarily consisting of Total Joint Replacement (TJR) procedures. The digital patient engagement system's email and text messages allowed patients and PSH staff to track outcomes, experience, and collaborate on post-surgical events. The average patient engagement was low (less than 40%). However, the average survey completion was 90%, i.e., if a patient responded to a survey on a particular day, on average patients finished 90% of the survey. Patient engagement was critically important to improving surgical care in rural areas. Digital longitudinal patient engagement implemented by PSH clinic was successful at rural community hospitals serving patients from 10+ surrounding counties.

Keywords

Patient engagement, perioperative surgical home, rural surgical outcomes research, longitudinal digital platform

Introduction

With increased demand of total joint replacements (TJR) in the United States (U.S.),[1] patient engagement has become a critical part in reducing surgical cost while ensuring patient safety, quality of service, and patient satisfaction.[2-4] Patient engagement is an active clinical process to coordinate closely with patients for preventive surgical care and to improve overall patient outcomes.[5] Engagement events like patient education and postoperative follow-ups play a vital role in the shared decision-making process that allows clinicians to counsel patients, establish pain management plans, and prepare for surgery.[6, 7] These events help clinicians monitor patient's recovery and overall quality of life, to intervene as necessary during the postoperative period to ensure patient satisfaction.[8] Past studies have demonstrated that tracking patient reported outcome measures (PROMs) via engagement events improved patient satisfaction and overall surgical outcomes including better pain management, faster recovery, lower rate of readmission, and reduced emergency department visits.[2, 3, 9] PROMs are health status reports that are received directly from the patients.[10] PROMs such as the Harris Hip Score, Knee Society Score, and Oxford Shoulder Score were typically collected for TJR procedures that were performed on hip, knee, and shoulder, respectively [11, 12]. These PROMs commonly focus on patient's feedback related to their current pain level, joint range of motion, functional or independent status, and ability to perform activities of daily living.[13-15]

Engagement platforms are emerging as one of the efficient ways to collect PROMs for TJR procedures.[16] These platforms like patient portals, mobile health, and chatbots utilize digital applications that are designed to automate activities including patient engagement throughout the 120-day perioperative period – 30-days preoperative to 90-days postoperative.[17] The spread of technologies such as smartphones, internet, and mobile services are conducive to the surge in utilizing engagement platforms for TJR procedures in the U.S.[16] Moreover, orthopedic clinicians are often overburdened with the increasing demand of TJR procedures. This makes it difficult for them to perform effective engagement events with patients through office consultations and postoperative clinic visits as frequently as needed.[17] The outbreak of COVID-19 exacerbated the issue of in-person patient engagement, forcing both patients and clinicians to interact virtually.[18] Engaging virtually using a digital platform has proven effective because it aids both clinicians and patients by minimizing the number of non-emergent clinical visits help to reduce clinical workload and surgical cost.[16, 19]

Another reason for utilizing the engagement platform is due to the burgeoning of a new coordinated surgical system in orthopedics – the Perioperative Surgical Home (PSH).[20] Compared to the traditional surgical system, the PSH is a coordinated interdisciplinary team encompassing all surgical care provided to patients from preoperative phase (30-days before surgery) through recovery.[20-22] In other words, in PSH, patient engagement is performed longitudinally throughout the perioperative period through physician co-management and nurse navigation. Longitudinal patient engagement in PSH includes the combination of both remote and in-person appointments.[21] The combination of in-person (such as preoperative assessment/education) and remote (virtual engagement platforms or phone) are convenient for longitudinal patient engagement, which in turn helps to promote shared decision-making and patient value through continued clinical interaction and management postoperatively.[19, 21, 23]

Recent studies illustrated that tracking PROMs using an engagement platform was effective and helped to increase patient satisfaction, surgery experience, and optimize surgical outcomes.[16, 17] For example, Lyman, Hidaka, Fields, Islam and Mayman[23] used a mobile health engagement platform for total hip arthroplasty (THA) and total knee arthroplasty (TKA) to longitudinally track step count postoperatively. Step count (PROM) was tracked once every two-weeks to six-months after surgery. Lyman, Hidaka, Fields, Islam and Mayman[23] found that 96% of the cohort engaged at least once in the engagement platform. This enabled Lyman, Hidaka, Fields, Islam and Mayman[23] to understand the pattern and association of how an increase in step count led to earlier patient recovery during the postoperative period ($p < 0.01$). Likewise, Holte, Molloy, Werth and Jevsevar[24] used a web-based engagement platform with hip and knee patients to track PROMs longitudinally for 12-months after surgery. PROMs like Patient-Reported Outcomes Measure Information System Global Physical Health (PROMIS-GPH), Hip Disability and Osteoarthritis Outcome Score (HOOS JR), Knee Disability and Osteoarthritis Outcome Score (KOOS JR), and patient satisfaction were successfully collected using the platform. Holte, Molloy, Werth and Jevsevar[24] observed that on average, more than 60% responded to all engagement opportunities through the engagement platform. Through the study, Holte, Molloy, Werth and Jevsevar[24] found that the use of the engagement platform was positively associated with rapid improvement and higher joint-specific function during the 12 months postoperative period ($p = 0.013$).

Despite these successes to engage with patients using the engagement platforms, limited research has evaluated orthopedic surgical outcomes and patient engagement for rural healthcare system.[25] Surgical care inequality is higher among rural community hospitals due to limited resources, socioeconomic differences, and poor access to healthcare.[26-28] Compared to urban settings, rural hospitals' surgical outcomes have higher odds of in-hospital mortality and higher costs of hospitalization,[29] because many rural patients are uninsured, older, and have one or more medical complications.[30, 31] In addition, the exceeding demand for TJRs can often overwhelm rural hospitals coordinating perioperative services. This results in inadequate communication, poor care continuity, limited patient engagement, and preventable complications.[32] Moreover, large geographical distances and remote communities often limit the ability to co-manage care across physicians.

Thus, this study longitudinally assessed patient outcomes of a rural community hospital that integrated Perioperative Surgical Home (PSH) utilizing digital PROMs. The objective of this paper was to explore the patient's response rate when longitudinally engaged over 120-days using a digital platform at a community hospital. The study expected that patient engagement would be challenging due to primitive geographically-limited digital infrastructure and duration of the extended perioperative follow-up of 120-days. Specifically, Montana ranks 50th for internet access in the U.S. where only 72.4% of the people living in Montana have access to broadband internet connection.[33]

Method

A rural community hospital formed a Perioperative Surgical Home (PSH) in October 2018. The PSH outpatient clinic was affiliated with the hospital and began assessing patients preoperatively for TJR including hip, knee, and shoulder replacements.[34, 35] The community hospital is an 83-bed, level III trauma center primarily serving three counties, but also provides care to 10+ surrounding counties in the region. After consent, all orthopedic and spine patients were enrolled in the digital tracking engagement platform (On-Q*Trac, Avanos Medical Inc., Alpharetta, Georgia) to assess longitudinal PROMs. The baseline patient characteristics included age, gender, surgery type, surgeon, and service modality (inpatient or outpatient). The research study was approved by the Montana State University Institutional Review Board (Approval# BM050819-EX).

PROM collection
PROMs were collected a total of nine times (within 30-days prior to surgery, day of the surgery, post-operative days 1, 2, 3, 7, 30, 60, and 90) to monitor and track recovery. Based on the patient's preference, a survey hyperlink was sent to them either by text message or email or by both to complete the digital self-assessment. Each survey event took an average of three minutes to complete. The self-assessment included questions related to pain, hospital readmission, emergency room visits, side effects, sleep, patient satisfaction, and recovery.

Questions on pain levels (active and resting) and pain compared to their expectations were tracked before and after surgery. Active and resting pain were recorded on a 10-point scale where 0 was no pain and 10 was severe pain. Patients responded to the pain experience, compared to their expectation, by selecting one of the Likert-scale options: much less, slightly less, as expected, slightly more, and much more. Questions about recovery were asked to monitor patient's progress, while performing activities of daily living (e.g., standing, walking). Patients were asked to select one of the options: cannot perform any activity, need human assistance, need assistance from an aid, can perform the activity on my own. Patients were asked to provide satisfaction regarding their pain management and overall surgery experience, by selecting one of the options: very satisfied, somewhat satisfied, neutral, somewhat unsatisfied, and very unsatisfied. Patients were also asked to select the following side effects if they had: none (no side effects), nausea, vomiting, drowsiness, dizziness, constipation, hallucination, and itching. Patients reported sleep interruptions due to pain after surgery (sleep interrupted - never, rarely, sometimes, often, and always.) Lastly, the patients were asked if had been readmitted or visited the emergency department (ED) during recovery.

There were fifty-seven (57) PROM questions; five questions for the pre-operative period, day of the surgery, and postoperative day 1, four questions for postoperative day 2, eight questions on postoperative days 3, 7, 30, and seven questions for postoperative days 60 and 90 (Appendix Table 1). Questions about pain and recovery (daily activities) were asked in all engagement surveys. PROMs including side effects and sleep interruption were asked on the first-week post-surgery; a sleep question was also asked on postoperative day 30. Questions on readmission/ED visits and patient satisfaction related to pain and surgery management were asked at the end of the engagement period i.e., on days 30, 60, and 90. Patient engagement was determined if a patient responded to at least one question (out of 57) in the engagement platform. A patient's survey completion was determined by how many questions were answered. The research team (health systems engineers and clinicians) collected and analyzed

Figure 1. The outcome dashboard for pain – VAS average pain and pain compared to expected
***N is the number of patients included in the dashboard and in this case, it is 1**

Figure 2. The outcome dashboard for recovery – daily activities, stand, and walk
***N is the number of patients included in the dashboard and in this case, it is 1**

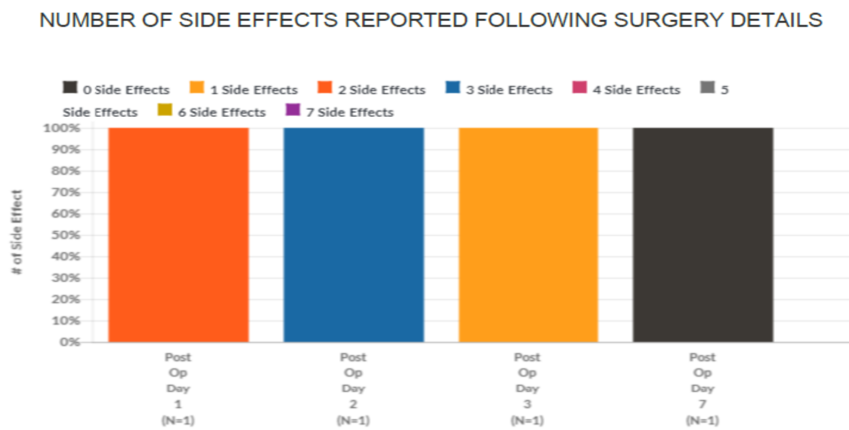
the data from patients enrolled in the engagement platform between November 2018 to March 2021.

Engagement Platform – dashboard and alerts

The outcomes reported by the patients were securely stored in an encrypted server and were accessed only by the authors and the clinicians requiring access. The On-Q*Trac engagement platform generated an outcome dashboard that helped clinicians monitor the PROMs. For example, Figures 1-3 exhibit a dashboard for pain, daily activities, and side effects of a specific patient (N=1). The clinicians also had the option to add multiple patients to the dashboard and examine the PROMs in an aggregate report. For example, the VAS Pain Average in Figure 1 exhibits the active and resting pain levels for one patient. If a clinician preferred to add more patients to the dashboard, then it will display the average active and resting pain levels of all patients (N) included in it. Correspondingly, the percentage of respondents in pain compared to expectations graph displays (Figure 1) the categories selected by the patients for different time points. In this case, there was only one patient included in the dashboard. Therefore, it shows 100% for the selected category in all time points. However, if there were two patients (N = 2) and both of them selected different categories for a particular day, there will be 50% for each category for that particular day. In other words, the percentage was calculated by the number of patients who responded to a particular category by the total number of patients who responded on the particular day. Figures 2 and 3 were interpreted similarly to Figure 1.

The engagement platform provided digital alerts through text messages or emails to PSH staff when a patient reported high pain (more than 7), visited an ER or was readmitted, or requested to speak with a clinician for a non-emergent issue. The nurse navigator in the PSH, who acted as a mediator, received these alerts and reached out to the patients by phone after consulting with the PSH team – anesthesiologist, surgeon, and hospitalist.

Figure 3. The outcome dashboard for side effects
***N is the number of patients included in the dashboard and in this case, it is 1**



Either the Fischer's exact test or Chi-square test for association was used to compare the categorical variables. The continuous variables were analyzed using the Mann-Whitney test or Student's t-test, as appropriate. Binomial logistic regression was used to fit the adjusted model of patient engagement with the baseline variables. All data handling, visualizations, and statistical analysis (alpha (α) = 0.05) were performed using R (V 4.0.3, Vienna, Austria).

Results

A total of 376 patients were enrolled in the digital platform. Seventy-five (n = 75) patients were excluded from this study because either they had spine procedures (n = 64) or not TJR procedures (n = 11) (Figure 4). Out of 301 TJR patients reviewed, the most common procedure was knee arthroplasty (n = 147, 49%) and included both total (n = 111) and unicompartmental (n = 28) procedures. A total of 134 (45%) hip arthroplasties were performed and included both total (n = 125) and partial procedures (n = 9). Lastly, 20 (6%) shoulder arthroplasties and revisions (n = 5) were included. Two hundred and eighteen (n = 218) patients (71%) responded to at least one question (out of 57 questions) in the engagement platform. The remaining 83 (29%) patients provided no feedback in the longitudinal engagement platform. Only 36

Figure 4. Patient allocation in the cohort study

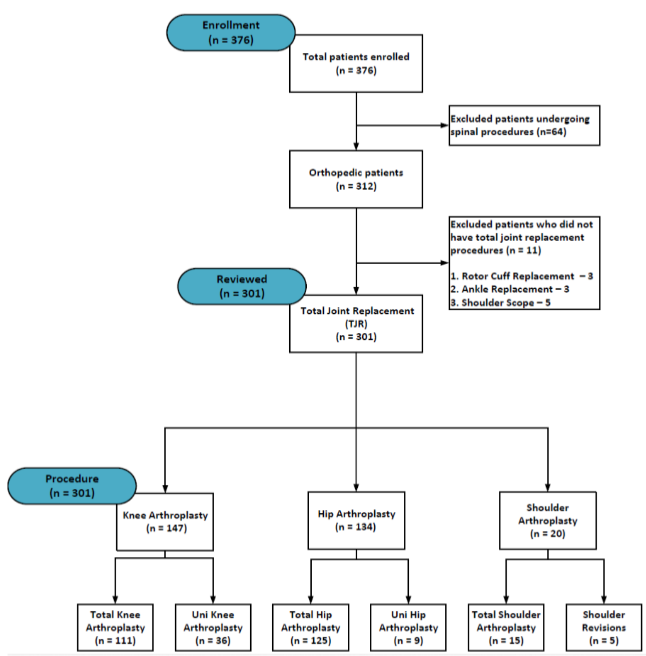


Table 1. Comparison of baseline characteristics between Engagement and Non-Engagement cohort

Variables		Engagement Cohort[4] (n = 218) Mean (SD) [Min, Max] or n(%)	Non-Engagement Cohort[5] (n = 83) Mean (SD) [Min, Max] or n(%)	P-Value
Age		68.3 (8) [39, 84]	68.3 (9.35) [35, 84]	0.74[1]
Gender				
	Male	79 (36%)	40 (48%)	0.08[2]
Procedure Type				0.6[3]
	Hip	100 (46%)	34 (41%)	
	Knee	105 (48%)	42 (51%)	
	Shoulder	13 (6%)	7 (8%)	
Service Modality				0.91[2]
	Inpatient	179 (82%)	67 (81%)	
	Outpatient	39 (18%)	16 (19%)	
Surgeon				0.04[3]
	A	183 (84%)	65 (74%)	
	B	12 (6%)	2 (2%)	
	C	12 (6%)	13 (16%)	
	D	11 (5%)	3 (4%)	

[1]Mann-Whitney Test. [2]Chi-Square Test. [3]Fischer's Exact Test. [4] Patients who used the engagement platform. [5]Patients who did not use the engagement platform

(12%) out of 218 participants responded to at least one question in all nine surveys, and out of those 36 patients, only 13 (4.3%) completed all 57 questions. Of the 301 TJR patients, there were on average 68.4 years old (standard deviation 8.4) and predominantly female (n = 182, 60%). Out of four surgeons, a single surgeon performed 82% of the included procedures. The service modality was predominantly inpatient (n = 82%) and was not associated with surgeons (P-value > 0.05) (Appendix Table 2).

Comparing the engagement (n = 218) and non-engagement cohort (n = 83), there was no significant difference observed in the baseline variables age, gender, procedure type, and service modality (P-value > 0.05) (Table 1). However, a moderate difference was observed between cohorts for the surgeon variable (P-value = 0.04). Surgeon C included more patients from the non-engagement cohort compared to the engagement cohort; vice-versa for surgeon B (Table 1).

Based on the logistic regression, the baseline variables age, procedure type, and service modality did not affect patient engagement on the digital platform (P-value > 0.05) (Table 2). There was a negligible effect observed in gender (P-value = 0.051), where the odds of male patients responding on the digital platform was 41% lower than female patients (OR = 0.59). Similarly, there was a difference observed in the adjusted analysis for the surgeon variable (P-value < 0.05). The odds of surgeon C patients responding on the engagement platform was 63% (OR = 37) lower than surgeon A patients (Table 2).

Of 301 patients, the most patient engagement was observed during the preoperative period, with 140 (46%) patients responding in the engagement platform, followed by on postoperative day 30, with 147 (49%) patients responding in the engagement platform (Figure 5). The lowest response rate was observed on postoperative day 90, with only 76 (25%) patients responding in the engagement platform (Figure 5). Regarding the survey completion, of 218 patients who responded in the engagement platform, the highest and lowest survey completion percentage per day was observed on postoperative days 60 and 30 with 93% and 86%, respectively (Figure 6). In other words, for day 60, a total of 89 patients responded in the engagement platform, where on average they completed more than six questions (6.55 questions, 93%) out of seven. In the same way, for day 30, 140 patients responded in the engagement platform, and on average, they completed around seven questions (6.88 questions, 86%) out of eight. The average overall survey completion percentage was 90% (i.e., if a patient responded to a survey on a particular day, on average, they finished 90% of the survey) (Figure 6).

Table 2. Adjusted analysis of Engagement and Non-Engagement cohort

Variables		Odds Ratio (OR)	95% CI	P-value
Age		1.01	0.98 - 1.04	0.62
Gender				0.051
	Male	0.59	0.34 - 1	
Procedure Type				
	Knee	0.88	0.49 - 1.58	0.88
	Shoulder	0.25	0.04 - 1.51	0.13
Service Modality				
	Outpatient	1.07	0.49 - 2.3	0.87
Surgeon				
	B	1.96	0.42 - 9.07	0.39
	C	0.37	0.15 - 0.88	0.03
	D	5.4	0.6 - 49	0.14

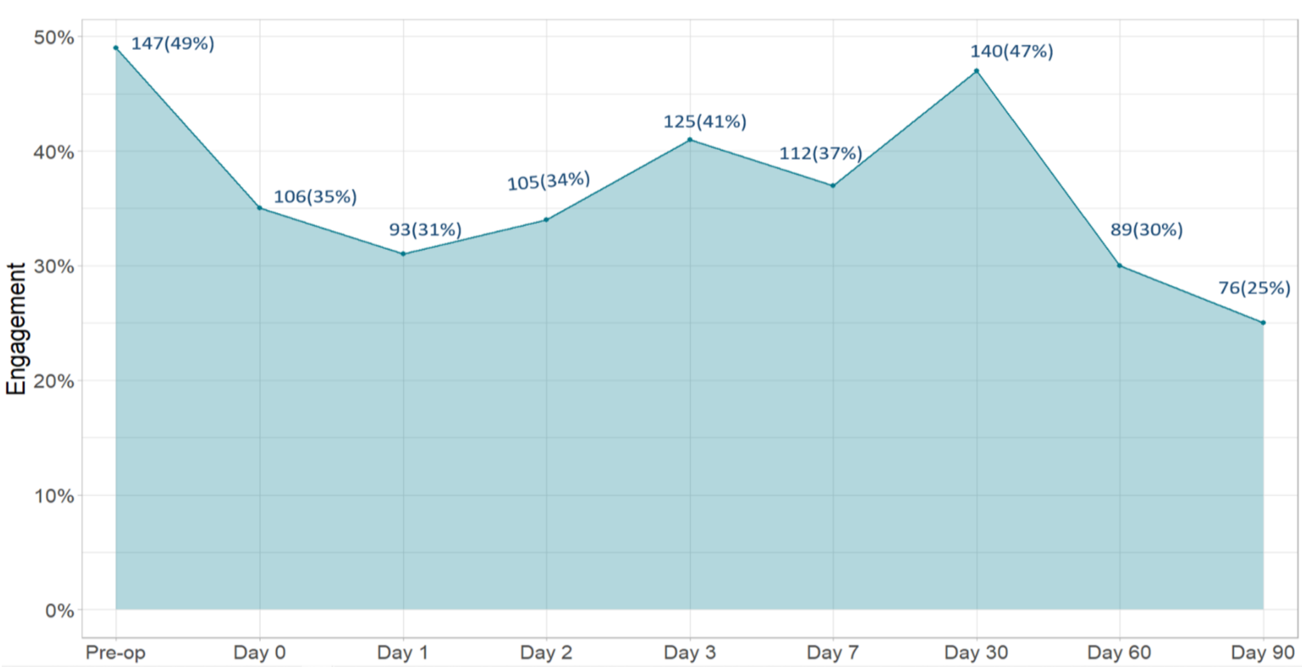
For a particular day, on average, the questions including resting pain, active pain, pain compared to expected, side effects, surgery satisfaction, and pain satisfaction had a higher completion percentage by the patients (greater than 95%) in the engagement platform (Appendix Table 3). The daily activities functional recovery question had the lowest average completion with 76% (Appendix Table 3).

More than 90% reported they were very satisfied or somewhat satisfied with the overall surgical experience and pain management; less than 5% reported they were unsatisfied. There was a total of 61 alerts received by PSH staff from patients: 12 ER alerts, 39 pain alerts, and 10 alerts for non-emergent issues. The alerts effectively helped PSH clinicians to facilitate patient care transitions, as needed.

Discussion

Patients in rural areas often face barriers and lack access to high-quality surgical care.[36] Generally, rural areas are more socioeconomically deprived and have less healthcare

Figure 5. Patient Engagement at different time points (out of 301 patients)

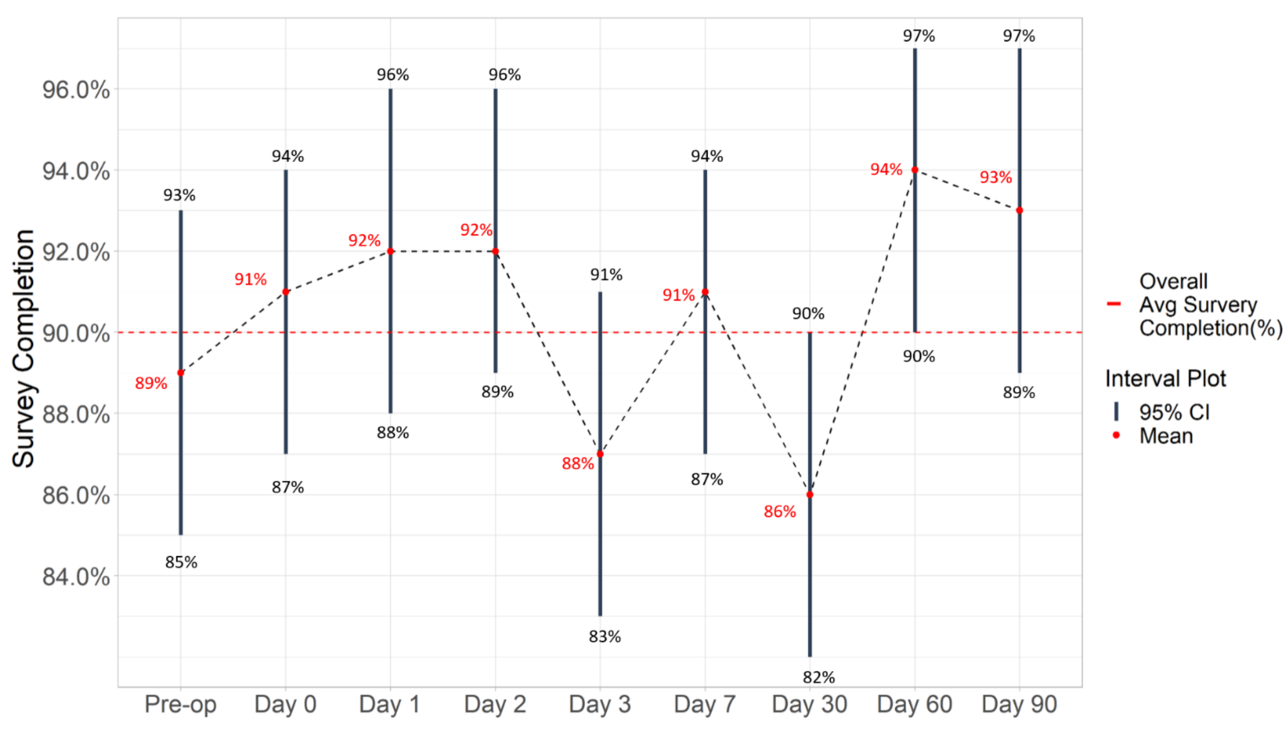


awareness, often resulting in less patient engagement and poorer outcomes.[37-39] This reflects negatively on patient satisfaction, i.e. , rural patients compared to urban patients, are often less satisfied with their surgical experience.[40, 41] In this study, a digital engagement platform was implemented by a rural community hospital that adopted the PSH system to improve TJR outcomes, value, and satisfaction. Similar to other studies, the engagement platform was found beneficial to monitor patients' progress longitudinally considering clinicians' workload and the COVID-19 outbreak, that restricted frequent in-person clinical visits.[17, 18]

In this setting, a longitudinal patient engagement was successfully performed on rural patients over the critical 120-day time-period (30 days preoperative to 90 days postoperative). Physician co-management as part of the PSH system incorporated a hospitalist, anesthesiologist, surgeon, and primary care physician, which was effective in educating and engaging rural patients, thus minimizing some barriers to surgical care. The patient engagement was highest during the preoperative period (0 to 30 before surgery) and then gradually decreased through postoperative period. Knapp, Keller, Mabee, Pillai and Frisch[42] and Molloy, Yong, Keswani, Keeney, Moschetti, Lucas and Jevsevar[43] demonstrated similar results, where most patient engagement was observed before surgery when engaged with TKA and THA patients. It was observed that patient education performed by the clinicians in the preoperative period led to more engagement and alleviated patient's anxiety. Education events not only helped patients build confidence and practice self-care, but also motivated them to engage with clinicians and receive more personalized care.[44] However, in the postoperative period, especially 30-days after the surgery, most patients were confident as they were almost or completely recovered, which made them less responsive on the engagement platform.[42]

Though a decrease in patient engagement was expected over time, a steady increase was observed on days 3 and 30 (Figure 5). The study accounts that patients' service modality and postoperative follow-ups by clinicians were contributing reasons. For instance, in this study, the majority of the patients were inpatients (82%) and on average, stayed two days after surgery. During the time in the hospital (Days 0, 1, and 2), patients preferred communicating with clinicians directly rather than providing feedback on the engagement platform. Whereas on day 3, most patients were discharged from the hospital and considered using the engagement platform to communicate with clinicians. Another main contributing reason for higher engagement on day 3, was due to follow-up of the nurse navigator in the PSH clinic. The PSH nurse performed regular follow-up with most patients via phone on day 3, and reminded them to utilize the engagement platform.[21] Similarly, around 30-days post-surgery, the surgeon or a PSH clinician followed up with patients by clinical visit or by phone and encouraged them to use the engagement platform. These factors explain why

Figure 6. Survey completion percentage at different time points (out of 218 patients)



there were low patient engagement on days 0, 1, and 2, and high engagement on days 3 and 30.

The average patient engagement was low (less than 40%) (Figure 5). The main reason was that many patients were inconsistent in responding to the survey at all time points (i.e., patients responded survey at a few time points but not all). Also, a total of 83 (29%) patients did not use the engagement platform at any time in the longitudinal period. Reasons that are associated with low and inconsistent engagement across the 120-day time period, include limited availability of internet, engagement platform connectivity/maintenance issues, and limited mobile service access.[45] Other reasons include patients' loss of interest, experiencing mental health issues or depression, or other personal obligations, including work.[37, 46] The adjusted logistic regression demonstrated that there was no association in baseline variables gender, service modality, and procedure type between patients who used the engagement platform and the patient who did not.[43] The surgeon variable had a moderate effect on patient engagement in the digital platform (P-value = 003). However, the study suspects this might be due to limited sample sizes (less than 10%) within the surgeon variable, as one surgeon performed the majority of the procedures.

Despite the low patient engagement, the average survey completion per day was comparatively high (90%) (Figure 6). In other words, many patients failed to respond to most engagement surveys (nine points), but if they responded to a survey on a particular day, on average patients finished most of the survey (~90%) (Figure 6). The PROM questions related to pain (active pain, resting pain, and pain compared to expected) had the highest average completion (more than 95%) in the engagement platform (Appendix Table 3). In the postoperative period, pain is an important PROM, and most patients prioritize communicating their pain with the clinicians for faster recovery and improved surgical experience.[42, 47-49] The functional recovery question - daily activities, had the lowest completion (76%). This was because the daily activity question was broader compared to other functional recovery questions: walking and standing (i.e., patients may not be sure what daily activities were referred to). Therefore, many patients skipped the daily activity question and instead, completed walking and standing functional recovery questions (Appendix Table 3).

Among the patients who responded on days 30, 60, and 90, more than 95 % reported they were satisfied with the surgery and the pain management. The engagement platform and PSH system enhanced patient care and value by educating and longitudinally engaging with patients, and reducing preventable surgical complications.[4] Patients experienced shorter length of stay, increased discharge to home, and reduced readmission rates and surgical site infection.[25, 35] These factors contributed to improving patient satisfaction that was lacking in rural hospitals.[32, 40, 50]

Limitations of this study, include an analysis of patient engagement and PROMs with limited covariates. Covariates such as insurance, employment status, marital status, economic background, American Society Anesthesiologists Score (ASA), and Body Mass Index have been associated with arthroplasty patients' responses on the engagement platform.[24, 51-54] Inclusion of these factors would have provided better clarity of patient engagement in rural surgical systems. Second, there was a digital platform server connectivity/maintenance outage period, which impacted an unknown number of responses during a 30-day window of this study. Third, the survey instrument used in this study was not entirely validated by a research community or an organization. However, the authors envision that the findings from this study will help future researchers and clinicians design an appropriate survey instrument with higher practicability and usability for TJR patients located in rural areas. Fourth, the study is retrospective, which may contain data collection biases that could alter the results and key findings.[55] Fifth, in conjunction with retrospective bias, the study also suspects the presence of inherent response bias. This might be more noticeable during the postoperative days one, two, and three when patients were not able to respond to the survey due to the factors associated with immediate post-surgery effects (tiredness, dizziness, loss of interest, etc.). Finally, this study was performed at a community hospital located in a micro-statistical area (with a population of less than 50,000). The results from this study may not be generalizable to more rural places (e.g., with a population of less than 10,000).

This study focused on exploring the patient's response rate when longitudinally engaged using the digital platform. The prospective of this study should concentrate on evaluating PROM outcomes such as pain, sleep, side effects, and recovery. It will be worthwhile to investigate how covariates age, gender, sleep, and pain medication influence on pain management and patient experience for TJR patients in the postoperative period.[47-49, 56] It will also be interesting to include using advanced sensors and wearables at rural community hospitals to remotely collect various patient data. The pressing interest would be collecting patient step count data which has shown promising results for clinicians in monitoring and measuring TJR patient's recovery after surgery.[23, 57-64] In the long term, the contribution of this study will immensely benefit surgical patients, clinicians, researchers, and healthcare professionals for delivering-high quality surgical care in the U.S., irrespective of socio-economic and socio-demographic differences.

Conclusion

Patient engagement was critically important to optimize care in a rural area served by community hospitals. Digital (email/text message) longitudinal engagement was successful across the 10+ rural county areas, as deployed by the PSH clinic. To the authors' knowledge, this study is the first of its kind to assess patient engagement at a rural community hospital with a coordinated PSH surgical system. Future research should assess engagement with rural patients and primary care managers in the region, to determine actual and perceived perioperative barriers. Additional future studies should focus on utilizing advanced analytics such as predictive modeling and machine learning should also be incorporated into future research to predict PROMs and improve rural surgical outcomes.[65, 66]

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Appendix

Appendix Table 1. Survey questions at each time point

	Preop	Day 0	Day 1	Day 2	Day 3	Day 7	Day 30	Day 60	Day 90	Question Frequency
Resting Pain	☑	☑	☑	☑	☑	☑	☑	☑	☑	**9**
Active Pain	☑	☑	☑	☑	☑	☑	☑	☑	☑	**9**
Pain Compared to Expected			☑		☑	☑				**3**
Functional Recovery - Daily Activities	☑	☑			☑	☑	☑	☑	☑	**7**
Functional Recovery - Standing	☑	☑			☑	☑	☑	☑	☑	**7**
Functional Recovery - Walking	☑	☑			☑	☑	☑	☑	☑	**7**
Side Effects			☑	☑	☑	☑				**4**
Sleep Interruption			☑	☑	☑	☑	☑			**5**
Patient Satisfaction on Pain Management							☑	☑	☑	**3**
Patient Satisfaction on Surgery							☑	☑	☑	**3**
Total Questions	**5**	**5**	**5**	**4**	**8**	**8**	**8**	**7**	**7**	**57**

Appendix Table 2. Association between surgeon and service modality variables

	Inpatient (n = 246)	Outpatient (n = 55)	P-Value (Fischer Exact Test)
Surgeon A	203 (86%)	45 (82%)	
Surgeon B	11 (4%)	3 (5%)	0.6
Surgeon C	19 (8%)	6 (11%)	
Surgeon D	13 (5%)	1 (2%)	

Appendix (cont'd.)

Appendix Table 3. Survey completion by patients

	Preop (n = 147)	Day 0 (n = 106)	Day 1 (n = 93)	Day 2 (n = 105)	Day 3 (n = 125)	Day 7 (n = 112)	Day 30 (n = 140)	Day 60 (n = 89)	Day 90 (n = 76)	Average Question Completion Percentage
Resting Pain	145 (99%)	105 (99%)	85 (91%)	100 (95%)	117 (94%)	106 (95%)	128 (91%)	87 (98%)	75 (99%)	**96%**
Active Pain	141 (96%)	105 (99%)	87 (94%)	100 (95%)	114 (91%)	107 (96%)	127 (91%)	87 (98%)	73 (96%)	**95%**
Pain Compared to Expected			88 (95%)		114 (91%)	108 (96%)				**94%**
Functional Recovery - Daily Activities	115 (78%)	79 (75%)			86 (69%)	82 (73%)	105 (75%)	73 (82%)	63 (83%)	**76%**
Functional Recovery - Standing	129 (88%)	96 (91%)			106 (85%)	104 (93%)	124 (89%)	84 (94%)	70 (92%)	**90%**
Functional Recovery - Walking	124 (84%)	96 (91%)			107 (92%)	103 (92%)	117 (84%)	82 (92%)	68 (89%)	**88%**
Side Effects			90 (97%)	96 (91%)	115 (95%)	106 (95%)				**94%**
Sleep Interruption			79 (85%)	91 (87%)	108 (86%)	97 (87%)	109 (78%)			**84%**
Patient Satisfaction on Pain Management							127 (91%)	85 (96%)	72 (95%)	**94%**
Patient Satisfaction on Surgery							127 (91%)	85 (96%)	72 (95%)	**94%**
Average Survey completion	**130.8 (89%)**	**96.2 (91%)**	**85.8 (92%)**	**96.75 (92%)**	**108.4 (87%)**	**101.6 (91%)**	**120.5 (86%)**	**83.3 (94%)**	**70.4 (93%)**	**90%**

*n here is the number of patients who responded on that particular day