Title of Project: Scaling and Spreading Electronic Capture of Patient-Reported Outcomes Using a National Surgical Quality Improvement Program

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STRUCTURED ABSTRACT

Purpose: The project aimed to use the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) to scale routine, health information technology-enabled collection of PROMs for quality improvement to the national level in ambulatory surgery, and to leverage the ACS NSQIP network of Collaboratives to spread its uptake.

Scope: The scope of the project included the implementation and refinement of the PROMs collection process at 65 US hospitals participating in the ACS NSQIP.

Methods: From 2/2020-3/2023, 65 NSQIP hospitals collected 4 Patient-Reported Outcomes Measurement Information System (PROMIS) measures (Global-10, Pain Interference 4a, Fatigue 4a, Physical Function 4a) and 2 measures of shared decision making (CollaboRATE and SDM-Q-9). Fifteen strategies to increase PROM collection rates were identified and operationalized. Each patient's PROMs were linked to their respective NSQIP data. To compare PROMs of patients with and without 30-day morbidity, reoperation, or readmission, we estimated adjusted mean differences using multivariable mixed regression accounting for patient- and case-mix.

Results: At project end, the median hospital-level collection rate was 40.7% (IQR 34.6-46.7%). Highest increases in collection rates occurred when both email and SMS text messaging were used, communications to patients were personalized with their surgeon's and hospital's information, and the number of reminders increased from 2 to 5. Patient age and insurance status contributed to nonresponse. Adjusting for patient- and case-mix, patients who experienced postoperative morbidity, compared to those without postoperative morbidity, had significantly worse physical function (adjusted mean difference 3.0, 95% confidence interval 2.5-3.4, $p<0.001$), fatigue (2.7, 2.2-3.3, $p<0.001$), pain interference (2.3, 1.8-2.8, $p<0.001$), and mental QoL (1.9, 1.4-2.4, $p<0.001$).

Keywords:

- Patient-Reported Outcomes (PROs)
- Quality Improvement
- Health IT
- ACS NSQIP
- Surgical Outcomes
- Patient-Reported Outcome Measures (PROMs)
- Patient Engagement

PURPOSE

The purpose of this study was to evaluate the feasibility of scaling and spreading a health IT-enabled PROMs implementation across the US using the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP). The intent was to learn from the implementation process to obtain generalizable knowledge and to understand how PROMs can identify quality improvement opportunities in patients undergoing surgery, specifically ambulatory surgery.

Objectives:

Aim 1: To demonstrate feasibility for widespread adoption of the routine, health IT-enabled capture of PROMs from surgical patients to at least 30 ACS NSQIP hospitals for quality improvement.

Aim 2: To identify and understand common (program-wide) and unique (institutional) best practices to spread the health IT-enabled PROM implementation.

Aim 3: To explore the potential of identifying quality improvement gaps with aggregated PROMs.

SCOPE

Background and Context:

By translating the patient's perspective into clinically relevant and quantifiable assessments of care delivery, patient-reported outcome measures (PROMs) hold great promise to improve care quality.

On an individual patient basis, PROMs can enhance patient-clinician communication, identify problematic symptoms and treatment priorities, facilitate shared decision-making, and, among advanced cancer patients, prolong life. In the aggregate, PROMs can also catalyze quality and performance improvement and as such, are increasingly incorporated into health care policy, global hospital rankings, and value-based health care initiatives across myriad conditions, particularly surgery. Current measures of surgical quality emphasize processes, adverse events (e.g., complications), and resource use, which are necessary to track, but do not provide a complete picture of the recovery, symptoms, and outcomes patients experience. PROMs provide vital information about patients who do not experience complications. However, the implementation of PROMs for surgical quality improvement remains restricted to single centers and has not been routinely ingrained into quality improvement thinking.

Settings:

Hospitals in the US participating in the NSQIP were recruited on a rolling basis to participate in this pragmatic implementation project conducted between February 2020 and April 2023. Though any hospital in the US participating in the NSQIP could participate, we capitalized on the ACS NSQIP network of Collaboratives to recruit hospitals through lectures and educational seminars.

The ACS NSQIP is a clinical registry that collects patient characteristics, perioperative details, and postoperative adverse events occurring within 30 days for quality improvement purposes. Nine different surgical specialties are included, including Cardiac Surgery, General Surgery, Obstetrics and Gynecology, Neurosurgery, Orthopedic Surgery, Otorhinolaryngology, Vascular Surgery, Plastic Surgery, Thoracic Surgery, and Urology. Trained individuals with clinical knowledge, called Surgical Clinical Reviewers (SCRs), abstract data directly from the medical record following standardized data definitions. SCRs are regularly audited to ensure data fidelity. Data definitions are updated periodically to reflect the current available evidence. Patients are identified postoperatively for accrual and systematically sampled following a selection algorithm to ensure case diversity. Voluntarily participating hospitals are provided biannually with their risk-adjusted outcomes benchmarked against all other participating hospitals to highlight quality improvement opportunities.

Participants:

The participants of the study included ambulatory surgical patients across the enrolled ACS NSQIP hospitals, surgical clinical reviewers, surgeon champions, and hospital administrators. These stakeholders play pivotal roles in both the collection and application of PROM data.

Incidence and Prevalence:

While the study does not directly address the incidence nor prevalence of a specific condition, it targeted adoption of PROMs in surgical patients. The study's enrollment grew from a pilot project with 11 sites in 2020 to including up to 65 hospitals at the end of the project, accruing 33,000 patients.

METHODS

Study Design:

The study employed a prospective, multi-site implementation design. It was structured to (Aim 1) assess the feasibility of health IT-enabled capture of PROMs across diverse healthcare settings within the ACS NSQIP. It also aimed to (Aim 2) identify best practices for PROM implementation and explore the potential of PROMs in identifying quality improvement opportunities. Ongoing analysis (Aim 3) explores the potential of identifying quality improvement gaps with aggregated PROMs. Detailed methodology by project aim is presented in Appendix 1.

Data Sources/Collection:

PROMs were collected via the ACS NSQIP PRO platform, an electronic, encrypted, HIPAA-compliant platform. Patient outcomes data was gathered from the ACS NSQIP registry. Hospital level characteristics were gathered from the 2021 American Hospital Association (AHA) Annual Hospital Survey Database and the NSQIP database.

Interventions:

Fifteen interventions were implemented via PDSA cycles to enhance participation and engagement (Figure 1).

Measures: The primary measures of the study were (Aims 1-3) the response rates to the PROM surveys and the enrollment of sites into the program. Four Patient-Reported Outcomes Measurement Information System (PROMIS) measures (Global-10, Pain Interference 4a, Fatigue 4a, Physical Function 4a) and two shared decision-making measures (9-item Shared Decision-Making Questionnaire [SDM-Q-9], CollaboRATE) were collected (Appendix 2). Electronic health records and specialized software platforms were used to disseminate surveys and collect responses. To identify best practices (Aim 2), feedback from participants, including surgical clinical reviewers, surgeon champions, and hospital administrators, was gathered through surveys and focus groups. Primary measures to identify quality improvement gaps (Aim 3) include morbidity, reoperation, readmission, and the above-mentioned PROMs.

Limitations: Some potential limitations of the study include:

- **Lack of baseline**: The NSQIP identifies and accrues patients after surgery, and thus it was not possible to identify patients preoperatively that would be accrued into the NSQIP. Therefore, we were not able to obtain a baseline PROM measurement.
- **Nonresponse Bias:** There may be a difference in who chooses to respond to the surveys, potentially skewing results.
- **Universal rather than condition specific PROMs**: As the NSQIP registry comprised of operations from a wide range of surgical specialties, we utilized universal rather than condition-specific PROMs in order to standardize the PROMs collected.
- **Sample Size and Diversity:** The varying size and type of participating hospitals within the NSQIP may influence the generalizability of the findings. Also, only US hospitals could participate due to regulatory issues with email and SMS text messaging.

RESULTS

Principal Findings:

Implementation activities and collection rates (Aims 1-3)

PDSA Cycles

Four Patient-Reported Outcomes Measurement Information System (PROMIS) measures (Global-10, Pain Interference 4a, Fatigue 4a, Physical Function 4a) and two shared decision-making measures (9-item Shared Decision-Making Questionnaire [SDM-Q-9], CollaboRATE) were collected.

Fifteen PDSA cycles were conducted to facilitate implementation, primarily targeting the Consolidated Framework for Implementation Research (CFIR) domains of Inner Setting (i.e., IT platform) and Individuals (i.e., patients) (Table 1). Four PDSA cycles involved SCR perspectives, including automated patient enrollment, a standardized phone call script explaining PROMs to patients, and single sign-on capability for the analytics dashboard. Two PDSA cycles targeted major changes to the electronic PROM collection platform. First, a dedicated PROM-specific analytics dashboard to review on-demand collection rates and aggregated PROM scores was created for each participating hospital. The remaining PDSA cycles focused on patient engagement, which often required platform functionality updates (i.e., categorized as either CFIR Inner Setting or Individuals domains).

Table 1. Implementation Activities and Plan-Do-Study-Act-Cycles.

PDSA Cycle Topic	Description	Date	CFIR Domain
Opt-out ability	Patients can opt-out from future communications.	Q2-2020	Individuals – Patients
Revised patient-facing language	Clearer explanation in communications sent to patients about why they should complete PROMs.	Q2-2020	Individuals – Patients
Analytics dashboard	Hospital-specific portal with on-demand analytics to review collection rates and PROM scores.	Q3-2020	Inner Setting
Patient enrollment	Removed the need for SCRs to manually send PROMs to patients.	Q3-2020	Individuals – SCRs
PROMs reports	Monthly summary reports on collection rates and PROM scores for each hospital compared to all other hospitals in the project.	Q3-2020	Individuals – SCRs & Leadership
SMS text messaging	Secure weblink to collect PROMs sent via text messaging instead of email.	Q1-2021	Inner Setting
Phone call script for PROMs	Standardized language for SCRs to explain PROMs to patients during telephone encounters.	Q2-2021	Individuals – SCRs
Layout design changes	Patient-facing user experience-based design changes.	Q3-2021	Individuals – Patients
PROM display order	The order of PROMs displayed to patients was rearranged.	Q3-2021, Q2-2022, Q4-2022	Individuals – Patients
Spanish language	Communications, PROMs, etc. available in Spanish.	Q4-2021	Individuals – Patients
Single-sign on capability	SCRs can use the same login credentials for the analytics dashboard and the NSQIP registry, and across different hospitals.	Q4-2021	Individuals – SCRs
Both email and SMS text messaging	Patients sent communications using both email and SMS text messaging rather than one or the other.	Q1-2022	Inner Setting
Personalized communications	Patient-facing communications customized with hospital and surgeon names in addition to ACS.	Q2-2022	Individuals – Patients
Informational pamphlets	Produced pamphlets describing the ACS NSQIP and PROMs for hospitals to provide to patients.	Q3-2022	Individuals – Patients
Reminders	Increased number and frequency of reminders sent to patients to complete PROMs.	Q3-2022	Individuals – Patients

Hospital-level

Sixty-five hospitals participated for median 21 months (IQR 16-26) and distributed PROMs to median 1844 patients (IQR 1247-2530). Two hospitals withdrew due to factors unrelated to the project.

The primary outcome was the collection rate, calculated as ≥1 PROM submitted per patient over either the project duration or per quarter by hospital. The target collection rate was ≥30%. The collection rate target was exceeded in Q3-2022 (Figure 1). We observed the highest increases in collection rates when both email and SMS text messaging were used (Q1-2022), communications to patients were personalized with their surgeon's and hospital's names (Q2-2022), and the number of reminders increased from 2 to 5 (Q3-2022). The average hospital collection rate significantly increased by 14.9% (95% CI 11.7-18.1%, $p<0.05$) in Q2-2022 and by another 11.9% (95% CI 8.8-15.0%, $p<0.05$) in Q3-2022, reaching a median maximum of 40.7% (IQR 34.6-46.7%) across hospitals (Figure 2).

Figure 1. Number of respondents and response rates during the project.

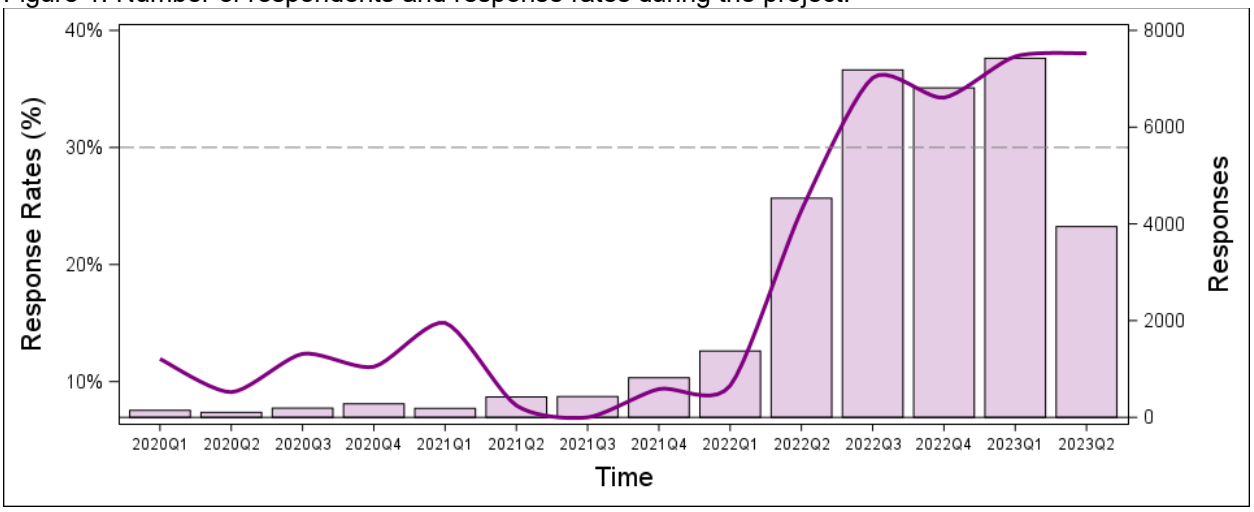
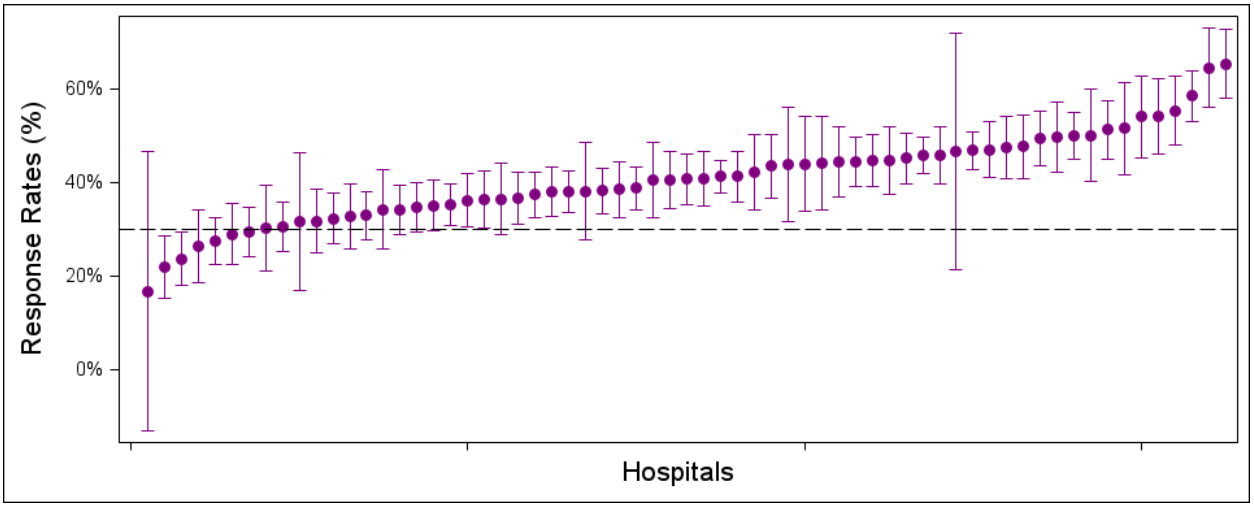


Figure 2. Highest response rate achieved by each hospital during the project.



Hospital characteristics were obtained from the 2021 American Hospital Association (AHA) Annual Hospital Survey Database and the NSQIP database. Hospitals were provided quarterly reports of their patient enrollment, PROM completion rates, and performance on PROMs overtime. A sample report is presented in Appendix 3.

Hospitals were geographically diverse, ten (15.4%) were non-teaching hospitals, and 39 (60.0%) had less than 500 beds (Table 2). The median proportion of inpatient Medicaid and Medicare days was 20.4% (IQR 12.5-26.3) and 47.8% (43.3-54.0%), respectively (Table 2). Hospitals achieving collection rates ≥30%, as compared to those who did not, were more often long-term participants in the NSQIP (70.7% vs. 28.6%, p=0.04) and minor teaching hospitals (56.9% vs. 14.3%, p=0.03) (Table 2). However, in multivariable analysis, no hospital characteristics examined were associated with collection rates ≥30% (Table 2). Of hospitals which achieved ≥30% collection rates, neither when a hospital joined (p=0.66) nor participation duration (p=0.11) were significant characteristics (Table 3). Long-time NSQIP participants and those with more NSQIP resource commitment were also not associated with collection rates ≥30% (Table 3).

Table 2. Characteristics of hospitals who did and did not achieve the target collection rate.

	Total (n=65)	Achieved collection rates ≥30% (n=58)	Did not achieve collection rates ≥30% (n=7)	*p*
Start year, n (%)				0.66
2020	11 (16.9)	11 (19.0)	0 (0.0)	
2021	23 (35.4)	20 (34.5)	3 (42.9)	
2022	31 (47.7)	27 (46.6)	4 (57.1)	
Duration in project, mo, median (IQR)	21 (16-26)	22 (16-29)	16 (12-25)	0.11
Initial collection rate ≥10%, n (%)	24 (36.9)	22 (37.9)	2 (28.6)	1.00
Years in NSQIP, n (%)				0.04
≤10	22 (33.8)	17 (29.3)	5 (71.4)	
>10	43 (66.2)	41 (70.7)	2 (28.6)	
SCR/FTE, median (IQR)	4 (2-8)	3 (1.5-8)	8 (4-19)	0.09
Bed size, n (%)				1.00
<500 beds	39 (60.0)	35 (60.3)	4 (57.1)	
≥500 beds	26 (40.0)	23 (39.7)	3 (42.9)	
Teaching hospital, n (%)				0.03
Major	21 (32.3)	18 (31.0)	3 (42.9)	
Minor	34 (52.3)	33 (56.9)	1 (14.3)	
Non-teaching	10 (15.4)	7 (12.1)	3 (42.9)	
Urbanicity, n (%)				0.45
Rural	5 (7.7)	4 (6.9)	1 (14.3)	
Urban	60 (92.3)	54 (93.1)	6 (85.7)	
The Joint Commission accreditation, n (%)	55 (84.6)	48 (82.8)	7 (100.0)	0.58
ACS CoC accreditation, n (%)	46 (70.8)	42 (72.4)	4 (57.1)	0.41
Critical access hospital, n (%)	2 (3.1)	2 (3.5)	0 (0.0)	1.00
Rural referral center, n (%)	17 (26.2)	15 (25.9)	2 (28.6)	1.00
PFAC*, n (%)	47 (74.6)	42 (75.0)	5 (71.4)	1.00
Quality and safety-based contracting*, n (%)	55 (87.3)	49 (87.5)	6 (85.7)	1.00
% Medicaid days, median (IQR)	20.4 (12.5-26.3)	20.0 (12.1-27.0)	23.9 (16.5-24.3)	0.83
% Medicare days, median (IQR)	47.8 (43.3-54.0)	47.6 (43.3-52.9)	54.9 (42.2-58.2)	0.20

IQR: interquartile range; NSQIP: National Surgical Quality Improvement Program; SCR: Surgical Clinical Reviewer; FTE: full-time equivalent; ACS: American College of Surgeons; CoC: Commission on Cancer; PFAC: Patient and Family Advisory Council; mo: months

* n=63

Table 3. Multivariable analysis of hospital characteristics associated with achieving ≥30% collection rates.

	Odds Ratio (95% Confidence Interval)
Start year	
2022	---
2021	1.2 (0.03-45.9)
2022	1.6 (0.01-314.9)
Duration in project, mo	1.1 (0.9-1.3)
Initial collection rate ≥10%	1.2 (0.2-7.2)
Years in NSQIP	
≤10	---
>10	4.5 (0.9-21.4)
SCR/FTE	1.0 (0.9-1.0)
Teaching hospital	
Major	1.0 (0.1-7.3)
Minor	4.5 (0.7-27.6)
Non-teaching	---
Urbanicity	
Rural	---
Urban	1.5 (0.1-20.8)
% Medicaid days	1.0 (0.9-1.1)
% Medicare days	1.0 (0.9-1.0)

SCR: Surgical Clinical Reviewer; FTE: full-time equivalent

Patient-level

PROMs were administered to 130365 patients, of which 4192 (3.2%) opted out of participation. Of the 33842 (26.0%) patients who responded, 26839 (79.3%) completed all 6 PROMs and 3555 (10.5%) completed only one. There were no missing items as patients were required to complete all items per PROM. 31493 (93.1%) patients completed PROMs on the same day they received the request. Patients completed PROMs a median 58 days (IQR 47-72) postoperatively. Only 507 (1.5%) patients completed PROMs in Spanish. In multivariate analysis, compared to non-respondents, respondents were more often older, non-Hispanic, White females with fewer comorbidities and Medicare coverage, though age and insurance status were the only factors with small effect sizes (Table 4). In multivariable analysis, factors associated with response to PROMs were increasing age, female sex, lower ASA class, obesity, chronic steroid use, and contact via email (Appendix 4a, supplemental tables).

Table 4. Characteristics of patients who responded to PROMs as compared to those who did not.

	Total (n=130365)	Respondents (n=33842)	Nonrespondents (n=96523)	*p*	Effect Size
Age, y, median (IQR)	60.1 (46.2-70.0)	64.9 (54.4-72.1)	58.0 (43.9-69.0)	<0.001	0.2
Female sex, n (%)	77369 (59.4)	20640 (61.0)	56729 (58.8)	<0.001	0.02
Race, n (%)				<0.001	0.09
White	95085 (72.9)	26802 (79.2)	68283 (70.7)		
Black	18788 (14.4)	3901 (11.5)	14887 (15.4)		
Asian	3993 (3.1)	871 (2.6)	3122 (3.2)		
Other	12499 (9.6)	2268 (6.7)	10231 (10.6)		
Hispanic ethnicity, n (%)	10187 (7.8)	1734 (5.1)	8453 (8.8)	<0.001	0.06
Insurance status, n (%)				<0.001	0.1
Commercial	65770 (50.5)	50117 (51.9)	15653 (46.3)		
Medicare	47937 (36.8)	32516 (33.7)	15421 (45.6)		
Medicaid	10059 (7.7)	8490 (8.8)	1569 (4.6)		
Self-pay	2529 (1.9)	2266 (2.4)	263 (0.8)		
Other	4070 (3.1)	3134 (3.3)	936 (2.8)		
Body mass index class, n (%)				<0.001	0.03
Underweight	1653 (1.3)	320 (1.0)	1333 (1.4)		
Normal	28033 (21.5)	7104 (21.0)	20929 (21.7)		
Overweight	40850 (31.3)	10951 (32.4)	29899 (31.0)		
Class 1	30961 (23.8)	8193 (24.2)	22768 (23.6)		

	Total (n=130365)	Respondents (n=33842)	Nonrespondents (n=96523)	*p*	Effect Size
Class 2	16566 (12.7)	4362 (12.9)	12204 (12.6)		
Class 3	12302 (9.4)	2912 (8.6)	9390 (9.7)		
ASA Classification, n (%)				<0.001	0.03
1-2	65289 (50.1)	16406 (48.5)	48883 (50.6)		
3	61172 (46.9)	16623 (49.1)	44549 (46.2)		
4-5	3904 (3.0)	813 (2.4)	3091 (3.2)		
Outpatient, n (%)	81773 (62.7)	21015 (62.1)	60758 (63.0)	0.006	<0.01
Emergency operation, n (%)	199 (0.2)	21 (0.1)	178 (0.2)	<0.001	0.01
Arrived from home, n (%)	128397 (98.5)	33506 (99.0)	94891 (98.3)	<0.001	0.03
Partially or totally dependent functional status, n (%)	1995 (1.5)	292 (0.9)	1703 (1.8)	<0.001	0.03
Current cigarette use, n (%)	16366 (12.6)	3095 (9.2)	13271 (13.8)	<0.001	0.1
Hypertension requiring medication, n (%)	61101 (46.9)	17667 (52.2)	43434 (45.0)	<0.001	0.06
Diabetes, n (%)				<0.001	0.02
IDDM	6596 (5.1)	1479 (4.4)	5117 (5.3)		
NIDDM	14432 (11.1)	3997 (11.8)	10435 (10.8)		
COPD, n (%)	4283 (3.3)	1092 (3.2)	3191 (3.3)	0.49	<0.01
Acute or chronic heart failure, n (%)	3722 (2.9)	899 (2.7)	2823 (2.9)	0.01	<0.01
Disseminated cancer, n (%)	2609 (2.0)	634 (1.9)	1975 (2.1)	0.05	<0.01
Dialysis, n (%)	1162 (0.9)	148 (0.4)	1014 (1.1)	<0.001	0.03
Chronic immunosuppressants, n (%)	6066 (4.7)	1728 (5.1)	4338 (4.5)	<0.001	0.01
Bleeding diathesis, n (%)	3758 (2.9)	845 (2.5)	2913 (3.0)	<0.001	0.01
Ascites, n (%)	350 (0.3)	85 (0.3)	265 (0.3)	0.50	<0.01
Preoperative SIRS or sepsis, n (%)	3511 (2.7)	470 (1.4)	3041 (3.2)	<0.001	0.05
Preoperative transfusion, n (%)	630 (0.5)	81 (0.2)	549 (0.6)	<0.001	0.02
Ventilator assistance, n (%)	65 (0.1)	7 (0.02)	58 (0.1)	0.004	<0.01
Acute kidney injury, n (%)	109 (0.1)	15 (0.04)	94 (0.1)	0.003	<0.01
Surgical specialty, n (%)				<0.001	0.06
Cardiothoracic Surgery	1922 (1.5)	569 (1.7)	1353 (1.4)		
General Surgery	51904 (39.8)	12832 (37.9)	39072 (40.5)		
Obstetrics and Gynecology	17032 (13.1)	4065 (12.0)	12967 (13.4)		
Neurosurgery	7408 (5.7)	1939 (5.7)	5469 (5.7)		
Orthopedic Surgery	28491 (21.9)	8402 (24.8)	20089 (20.8)		
Otorhinolaryngology	3829 (2.9)	804 (2.4)	3025 (3.1)		
Plastic Surgery	4405 (3.4)	1087 (3.2)	3318 (3.4)		
Urology	11185 (8.6)	3296 (9.7)	7889 (8.2)		
Vascular Surgery	4189 (3.2)	848 (2.5)	3341 (3.5)		
30-day Complications, n (%)					
Morbidity	6735 (5.2)	1592 (4.7)	5143 (5.3)	<0.001	0.01
Reoperation	2817 (2.2)	613 (1.8)	2204 (2.3)	<0.001	0.01
Readmission	5611 (4.3)	1268 (3.8)	4343 (4.5)	<0.001	0.02

IQR: interquartile range; ASA: American Society of Anesthesiologists; IDDM: insulin-dependent diabetes mellitus; NIDDM: non-insulin-dependent diabetes mellitus; COPD: chronic obstructive pulmonary disease; SIRS: systemic inflammatory response syndrome

Starting in Q3 2022, patients could respond via text messaging or email. Patients were more likely to respond when prompted by email as opposed to SMS text messaging (28.3% vs. 16.1%, p<0.001), though both were used. Patients who completed PROMs by SMS text messaging, as compared to email, were less often female (58.9% vs. 61.5%, p=0.008) and more often Hispanic (7.8% vs. 5.1%, p<0.001) with Medicare coverage (47.0% vs. 44.7%, p<0.001) (Appendix 4b, supplemental tables). Respondents after communications were personalized with hospital and surgeon names (i.e., Q2-2022), compared to before, were more often Hispanic or Black undergoing outpatient operations (Appendix 4c, supplemental tables).

Qualitative findings (Aim 2)

Three focus groups of 11 hospital quality team members from 8 hospitals were conducted (Table 5). Motivations involved leadership enthusiasm for the project to obtain novel data that could improve care quality. Participants identified PROMs can help "to make sure the outcome is something [patients] want," and that "Patient perception should be important to all hospitals because their perception is their reality." All participants identified the COVID-19 pandemic as a major barrier.

Eight 1:1 interviews with patients (4 female, 4 male, ages 34-78 years, 4 academic medical centers) were conducted. All patients voiced the importance of PROMs: "What else matters besides how the patient is doing?" and "There are things surgeons don't know and don't ask." Altruism ("This can make things better for everyone.") was also a major theme. Patients also voiced concerns about the trustworthiness of communications ("It can be hard to trust…a text or email that is unfamiliar."). To improve PROMs collection, patients stated that they must understand the purpose ("You need to let patients know what is the value in taking the time to do this…"), view the PROMs as relevant ("Needs to be short and to the point."), and be able to complete PROMs easily ("If it's not well designed, I'm going to stop in the middle.").

Qualitative study results highlighted common themes of the importance of PROMs, altruism, ease of use of data collection platform, understanding the underlying importance of PROMs, and concerns about the trustworthiness of unfamiliar technological communication methods.

Table 5. Representative Quotes from Qualitative Work during Implementation.

Theme Explored	Quote	CFIR Domain(s)
Focus Groups of Hospital Quality Team Members		
Motivation for Participation	"...quantify sentiments the patients have about surgeries that are not usually qualified...That will not be documented but are still critical to understand."	Innovation, Outer Setting – Local Attitudes, Inner Setting – Culture, Individuals – Characteristics
	"...having people so excited about it, you don't have a choice but to also be part of it."	Inner Setting – Culture, Individuals – Roles, Individuals – Characteristics
Importance of PROMs	"Patient perception should be important to all hospitals because their perception is their reality."	Outer Setting, Inner Setting, Individuals
	"...make sure the outcome is something [patients] want."	Outer Setting, Inner Setting
	"You get a better understanding of the patient point of view really, and there's no pressure for anyone."	Inner Setting
Barriers and Facilitators to Implementation	"You either want to do this or you don't. I don't think it's that complicated at all."	Individuals, Implementation Process
1:1 Interviews with Patients		
Value of PROMs	"What else matters besides how the patient is doing?	Innovation, Individuals
	"There are things surgeons don't know and don't ask."	Innovation, Inner Setting, Individuals
	"Surgery is a major thing."	Innovation, Individuals
Motivation for Completing PROMs	"...careful balance between questions that are easy to answer but that give actionable information."	Inner Setting, Individuals, Implementation Process
	"...if it starts going too broad then you're like 'OK, what are they gathering here?'"	Individuals, Implementation Process
	"You need to let patients know what is the value in taking the time to do this...besides just 'your opinion matters to us.'"	Individuals, Implementation Process
Barriers to Completing PROMs	"It can be hard to trust the veracity of a text or email that is unfamiliar"	Individuals, Implementation Process
	"Needs to be short and to the point."	Individuals, Implementation Process
	"If it's here's one question and then it starts multiplying I'm like 'Oh my God what happened here' then you say 'Forget it.'"	Individuals, Implementation Process
	"If it's not well-designed I'm going to stop in the middle."	Individuals, Implementation Process
	"Typing long answers in by text is...I'm not going to do that."	Individuals, Implementation Process

Quality improvement gap identification (Aim 3)

A separate patient level analysis was conducted to identify potential quality improvement targets. In this analysis, 33842 patients with median age 65 years (IQR 54-72) reported PROMs at a median 58 days (IQR 47-72) postoperatively, of which 20640 (61.0%) were female, 3901 (11.5%) Black, 17433 (51.5%) ASA Physical Status 3/4, and 21015 (62.1%) procedures were outpatient. The five most common procedures were knee replacement (3141; 9.3%), hysterectomy (2865, 8.5%), colorectal operations (2561, 7.6%), hernia repair (2554, 7.5%), and hip replacement (2111, 6.2%). Morbidity, reoperation, and readmission occurred in 1592 (4.7%), 613 (1.8%), and 1268 (3.8%) patients, respectively. Though no complications occurred in 31210 (92.2%) patients, 10586 (33.9%) had PROMs 1-SD or more below the national average and were more often older, morbidly obese, and with more comorbidities. Adjusting for patient- and case-mix, patients who experienced postoperative morbidity, compared to those without, had significantly worse physical function (adjusted mean difference 3.0, 95% confidence interval 2.5-3.4, $p<0.001$), fatigue (2.7, 2.2-3.3, $p<0.001$), pain interference (2.3, 1.8-2.8, $p<0.001$), and mental QoL (1.9, 1.4-2.4, $p<0.001$). Similar significant differences between patients with and without readmission and/or reoperation were evident on all PROMIS measures. Adjusting for patient- and case-mix, patients with any complication had 1.7-times greater odds (95% CI 1.6-1.8; $p<0.001$) of reporting PROMs 1-SD or more below the national average.

Discussion:

In this large-scale project to implement electronic PROMs collection into the NSQIP, 65 hospitals participated and the PROMs collection rate target of ≥30% was exceeded in the third year. Strategies that contributed to success were likely cumulative and involved the CFIR domains of Inner Setting and Individuals. Personalizing the invitation message to patients with their surgeon's and hospital's names, use of two communication modes and multiple reminders were particularly impactful. Qualitative interviews highlighted that patients must understand why they are completing PROMs, especially when PROMs are collected for purposes outside of direct clinical care, like for quality improvement.

No identifiable hospital characteristic contributed to achieving collection rates ≥30%, suggesting that the collection processes were applicable to all hospitals in this cohort and more dependent on platform functionality and patient engagement. PROMs scores were well-distributed, reinforcing the ability of PROMs data to detect differences among surgical patients.

Ninety percent of hospitals achieved the target collection rate of ≥30% and nine exceeded 50%, suggesting that further substantive increases are possible with continued process improvements. Based upon existing experience with national health surveys in the US, collection rates range between 30-50%. Though lower than survey research standards, high-stakes decisions are nonetheless made with these data. For instance, the Consumer Assessment of Healthcare Providers and Systems Hospital Survey (HCAHPS) achieved a median 31% collection rate in 2021-2022 using mail and telephone modes. As the Centers for Medicare and Medicaid Services (CMS) now mandates PROMs to evaluate the care quality of total joint replacement with significant financial consequences, the discussion of a lower yet useful collection rate will be further amplified.

A key takeaway from our findings is that health information technology (HIT) matters greatly to the success of implementing PROMs. To minimize costs, maximize patient contact, and ensure program sustainability, both email and SMS text messaging were used to collect PROMs. An online questionnaire requires less time and money to administer while also allowing prompt communication, automation, user-friendly design, and back-end data analytics. More than 90% of patients completed PROMs on the same day and almost 20% did so using text messaging, suggesting that multiple modes are important. We also observed increased collection rates when the number and frequency of automated reminders were increased, leveraging technology rather than human effort.

However, we encountered problems relying on HIT, such as difficulties registering emails and communications ending up as spam in already crowded inboxes. Though these errors were quickly identified with the availability of an analytics dashboard, using more modes, such as paper-based mail or telephone, might further increase collection rates but at considerable cost. Whether this increased cost is justifiable is unknown. Similarly, more reminders may affect how willing a patient is to respond in the long

term. A balance between the number of longitudinal assessments needs to be weighed against the number of reminders sent.

We utilized a blended approach of implementation science and quality improvement methods. The Institute for Healthcare Improvement (IHI) Framework for Spread and the CFIR provided the theoretical foundation and implementation framework, respectively, for the project, aiming to spread the innovation across the NSQIP while obtaining generalizable knowledge applicable beyond the NSQIP ecosystem. The spread of new ideas and approaches requires consideration of local contexts, which is foundational to quality improvement methods. Therefore, we operationalized the project using PDSA cycles. Fifteen were conducted, often in parallel and targeted to specific hospital needs with solutions implemented across all participating hospitals. Improvements in collection rates were cumulative with effects occurring over time. Though this precluded our ability to systematically identify singular causes of incremental increases in collection rates, much like a bundle, we believe all components are necessary to increase and sustain collection rates, particularly the use of multiple modes (i.e., email and text messaging), personalization of communications with patients to engender trust, and increasing reminder frequency. Currently, more than six months after the project closed, collection rates remain sustained at approximately 40%, underscoring the importance of these cumulative strategies.

In the NSQIP study, patients with complications reported statistically and clinically poorer PROMs. In addition, over 30% of patients without complications reported below-average PROMs independent of procedure type. A study limitation includes lack of baseline data, without which we are unable to account for or hypothesize about the rationale for patient-level differences in PROMs. Identifying solutions to improve PROMs after surgery remains a quality improvement opportunity. This study shows the necessity of incorporating PROMs into the quality assessment for patients undergoing a wide selection of surgical operations.

Conclusions: Routine capture of PROMs in surgical patients is feasible and can be effectively scaled across the ACS NSQIP and beyond. Interventions to improve patient engagement were successful, leading to higher response rates and richer data for quality improvement initiatives.

Significance: The findings underscore the significance of PROMs in providing a comprehensive view of surgical outcomes from the patient's perspective. The study's success in improving response rates and integrating PROMs into the ACS NSQIP signifies a meaningful advance in patient-centered surgical care.

Implications: This project demonstrates that the large-scale electronic collection of PROMs into the NSQIP is not only feasible but is also a notable step towards improving what matters most to patients. The study is the first in the nation to implement PROMs effectively on such scale for surgical quality improvement. Continued work is ongoing to incorporate baseline and longitudinal measurements as well as the incorporation of condition-specific PROMs. Interoperability standards are also a central focus of ongoing work. This work sets the stage for future quality measurement development (i.e., PRO-PMs) and accelerates value-based healthcare transformation.

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Submitted abstracts

Liu JB, Temple LK, Moturu A, Kaur M, Edelen MO, Ko CY, Pusic AL. Evaluating Hospital Surgical Quality with Patient-Reported Shared Decision Making. 31st Annual Conference of the International Society of Quality of Life Research (ISOQOL). Cologne, Germany. October 13-16, 2024. Under consideration.

Appendix 1. Detailed Methodology by project aims.

AIM 1: Demonstrate feasibility for widespread adoption of the routine, health IT-enabled capture of PROMs from ambulatory surgical patients to at least 30 ACS NSQIP hospitals for quality improvement.

1. Program Launch Team Formation: In 2019, a team comprising a postdoctoral fellow, statistician, IT specialist, and managers for health-IT platform, contracts, and hospital collaborations was assembled at the American College of Surgeons to design, launch, and maintain a national system for collecting and analyzing patient-reported outcome data.
2. PROM Measure Selection: Based on qualitative data from participating sites (see Aim 2), the PROM measures were revised from the initial proposal. Six validated instruments were selected to assess global physical health, mental health, pain interference, fatigue, physical function, and shared decision-making: PROMIS® Global, PROMIS® Pain Interference 4a, PROMIS® Fatigue 4a, PROMIS® Physical Function 4a, CollaboRATE™, and SDM-Q-9. Together, these 34 items represent a significant reduction from the 45 questions in the previous alpha pilot.
3. Project Kickoff Meeting: A formal kickoff meeting was held on October 28th, 2019, at the ACS Clinical Congress in San Francisco. Attended by principal investigators, co-investigators, and representatives from participating hospitals (approximately 30 individuals), the overall project design, health-IT PROM collection platform demonstration, and timeline for milestones leading to launch were discussed.
4. Health-IT Platform Enhancement: Near the end of 2019, the PROM collection platform underwent development and testing for workflow, patient and provider interfaces, and HIPAA-compliant security enhancements. User acceptance testing was completed in January 2020.
5. Official Program Launch: Onboarding webinars instructing participating sites on program workflow and patient enrollment processes were held on January 23rd and 31st, 2020. The health-IT PROM collection program was officially launched on February 3rd, 2020, with 32 enrolled sites currently collecting surveys for the project. A few additional sites have expressed interest in joining.
6. Monthly Participant Webinars: Starting May 2020, monthly webinars were conducted with participating sites. These webinars discussed patient enrollment, process improvements, and received direct feedback on potential barriers to patient enrollment.
7. Addressing Existing Institutional PROM Collection Barrier: During onboarding webinars and an April 2020 survey (described in Aim 2), several sites reported administrative concerns about overlapping NSQIP PROM collection efforts with their own institutional PROMs, potentially leading to duplicate data collection for some patients. As a feasibility study, identifying and addressing such barriers was central. Following a Plan-Do-Study-Act (PDSA) framework, an intervention allowing site registrars to opt out specific patients of NSQIP PROM collection was implemented on July 28, 2020. Subsequent sites and patient-level enrollment were monitored for improvement.
8. Patient Recruitment Language Modification: To increase patient responses, the initial patient contact email language was modified on July 28, 2020, to be more patient-friendly and without specifying the number of brief (<10 questions) instruments, which may have discouraged responses due to perceived time commitment. Patient response rates were monitored post-implementation for improvement.
9. Participant Data Portal Development: Responding to participants' interest in accessing institutional data for quality improvement, a portal for sites to access institutional reports and data was developed using a PDSA framework and launched on October 9, 2020.
10. Site Recruitment Outreach Efforts: Leveraging existing networks within the American College of Surgeons, various efforts were made to recruit additional sites:
    a. At the 2020 ACS Quality and Safety Virtual Conference (August 21-24, 2020) with over 10,000 registered attendees, a virtual plenary panel discussion highlighted the importance of PROMs in surgery and participation in this PROM collection project. Presenters included Drs. Larissa Temple, Andrea Pusic, and Brian Brajcich. Additionally, a "fireside chat" with Dr. Andrea Pusic provided further details on PROMs and the project.
    b. Following a presentation at the annual meeting of ACS NSQIP hospital collaborative leaders, multiple leaders requested information on enrolling hospitals within their collaboratives. The program was presented at the Upstate New York Surgical Quality Initiative (UNYSQI) meeting on 10/7/20, leading to three additional hospitals initiating the enrollment process.

    c. The 2021 Quality and Safety Conference included another PROMs panel session with Dr. Andrea Pusic, Dr. Courtney Collins, Dr. Numa Perez, and Dr. Larissa Temple, discussing Barriers and Solutions to Scaling PROMs, PROMs and Mobile Health Apps to Improve Disparities in Surgical Care, and PROMs for Postoperative Symptom Monitoring after Discharge.
    d. Site recruitment efforts targeted hospital systems to enroll groups of hospitals simultaneously.
11. Identification of community hospitals as ideal targets for recruitment: We are focusing recruitment on smaller community hospitals, which are more likely to benefit from our PROM collection platform. We held a virtual webinar with representatives of participating community hospitals on 11/12/2021 and continue to recruit through webinars and targeted outreach.
12. Use of SMS (text messaging) for patient contact: Based on feedback, we are implementing text messaging for patient recruitment, as some sites may lack e-mail addresses for all patients, and texts have higher read rates. Patients with mobile numbers will be contacted via text; those with only e-mail will be recruited via e-mail. This modification was implemented on 2/19/2021.
13. Continued enrollment of participating sites: We enrolled sites to reach the goal of 15-20 participants during Wave 1 (until Q2 2021). Despite COVID-19's impact, the team continued marketing the initiative. In January 2021, 20 new sites were enrolled and began data collection in April 2021. We currently have 63 enrolled sites.
14. Identification of existing institutional PROM collection as a potential barrier to participation and plan for addressing this barrier: The April 2020 survey identified additional labor for PROM collection as a potential barrier. As the PROM platform requires minimal workflow changes, this barrier was attributed to incomplete education about the process and expectations. Recruitment language has been modified to emphasize the minimal effort needed, and sites can meet with a Co-Investigator to discuss the process in detail.
15. Addition of Spanish-language capability: To increase response rates among Spanish-speaking patients and minimize non-response bias, we are implementing Spanish-language PROM instruments, with translations available for all included instruments. This feature went live in December 2021.

AIM 2: Identify and understand common (program-wide) and unique (institutional) best practices to spread the health IT-enabled PROM implementation through qualitative study.

1. Alpha Pilot Survey: Following the alpha pilot study, a survey was administered to surgical clinical reviewers and surgeon champions at participating sites to identify barriers encountered in PROM collection and gather suggestions for improvement. Completed by 16 individuals, the survey results were used to enhance the PROM collection platform (See Aim 1).
2. Survey of Unenrolled Sites: In April 2020, a survey was disseminated to invited sites that had not yet enrolled in PROM collection to identify potential barriers preventing their enrollment.
3. Monitoring Hospital Response Rates: Patient response rates, currently ranging from 7.1% to 17.4%, are being monitored at the individual hospital level to identify high and low-performing sites. Best practices for patient enrollment will be identified at high-performing sites, and barriers will be identified at low-performing sites.
4. Focus Group Interviews: In June 2021, separate focus group interview sessions were conducted with patients, surgeons, and hospital administrators from the 31 enrolled sites to understand the factors that motivated, supported, and impeded the implementation effort.
5. Identifying and Addressing Barriers: Barriers and solutions to implementation will be identified during both PDSA cycles (Aim 1) and qualitative studies at the end of each implementation cohort (Aim 2). Strategies identified will be incorporated into an educational curriculum, potentially including website development, infographics, presentation content, videos, and other guides and toolkits, targeted at hospital administrators, surgeons, and patients. Results from qualitative analyses will be used to build "best practice toolkits" to ensure long-term program sustainability and further spread.
6. Virtual Patient Focus Groups: Virtual focus groups with patients from participating sites were held to document the barriers they face in completing the surveys, with the goal of making the PROMs experience as easy and least time-consuming as possible.

AIM 3: Explore the potential of identifying quality improvement gaps with aggregated PROMs. The analysis for this aim is currently ongoing.

1. Linking PROMs to NSQIP Data: From February 2020 to March 2023, 65 NSQIP hospitals collected 4 PROMIS measures assessing physical function, fatigue, pain interference, and mental quality of life (QoL). Each patient's PROMs were linked to their respective NSQIP data. To compare PROMs of patients with and without 30-day morbidity, reoperation, or readmission, we estimated adjusted mean differences using multivariable mixed regression accounting for patient- and case-mix. We also compared PROMIS scores in surgical patients to the national population and evaluated patients with and without any complications who also reported PROMs one standard deviation (1-SD) or more below the national average.
2. Exploring Correlations and Identifying Quality Gaps: We will explore the ability of PROMs data to be correlated with clinical outcomes to derive insights into further surgical quality gaps; that is, identify providers with low complication rates and positive PROMs. For these exploratory analyses, we hypothesize that performance on clinical outcomes will differ as compared to performance on PROMs, both at the hospital and surgeon levels. In addition to the adjusted analyses described, raw unadjusted frequencies will also be reported back to participating hospitals. When available, raw unadjusted results will also be compared to normative data for the PROMs. These results will be compiled into reports for each participating hospital containing both clinical outcomes and PROMs comparing its performance to all participating hospitals. All statistical analyses will use SAS (SAS Institute; Cary, NC).
3. Future Analysis and Reliability Assessment: For future analysis, each appropriate PROM variation at the hospital and surgeon levels will be assessed separately using hierarchical multivariable regression models following previously reported methodology, whereby hospitals and surgeons function as random intercepts and risk adjustment variables as fixed effects. Following previously published methodology, variance partitioning techniques will be used to assess reliability. Statistical reliability ranges from 0 to 1 and reflects sample size, event rate, and variance within each level of aggregation, and conceptually represents the "signal-to-noise" ratio. That is, reliability provides a metric to assess the confidence that performance on PROMs is real versus simply noise. The sample size needed to obtain reliability levels of 0.4, 0.7, and 0.9 will be calculated. Then, the number of hospitals and surgeons that meet these levels of reliability will be estimated. The analysis for the shared decision-making measures (SDM-Q-9 and CollaboRATE) will be submitted to AHRQ as an addendum. These measures do not need baseline, pre-surgery assessments for comparison as they are measures of the patient's perception of shared decision-making during the surgical process itself.

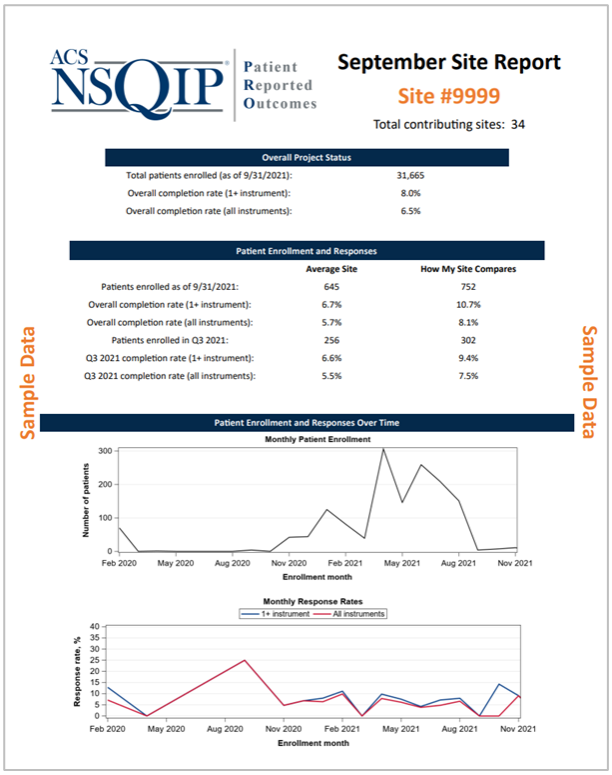
Appendix 2. PROM descriptions

Patient-Reported Outcomes Measurement Information System (PROMIS) measures are standardized to the US general population with mean 50 and standard deviation 10, where higher scores reflect more of the domain being measured. For example, a Pain Interference 4a score of 60 means one standard deviation more (i.e., worse) pain interference. As a universal, global PROM, the PROMIS Global-10 generates a physical component score (PCS) and a mental component score (MCS). Please see https://www.healthmeasures.net/explore-measurement-systems/promis for more information.

The 9-item Shared Decision-Making Questionnaire (SDM-Q-9) is a patient-reported outcome measure that evaluates the extent to which patients feel involved in the healthcare decision-making process, with scores ranging from 0 to 100. Higher scores indicate better perceived quality of shared decision-making, while lower scores suggest a need for improvement in the patient-provider interaction.

The CollaboRATE measure is a patient-reported outcome measure that assesses the patient's perception of how well healthcare providers involve them in the shared decision-making process, using three brief questions rated on a 10-point scale. Higher average scores (ranging from 0 to 9) indicate better collaboration between the patient and healthcare provider, while lower scores suggest a need for improvement in patient-provider communication.

Appendix 3. Sample site report



ACS NSQIP Patient Reported Outcomes

September Site Report

Site #9999

Total contributing sites: 34

Overall Project Status	
Total patients enrolled (as of 9/31/2021):	31,665
Overall completion rate (1+ instrument):	8.0%
Overall completion rate (all instruments):	6.5%

Patient Enrollment and Responses	Average Site	How My Site Compares
Patients enrolled as of 9/31/2021:	645	752
Overall completion rate (1+ instrument):	6.7%	10.7%
Overall completion rate (all instruments):	5.7%	8.1%
Patients enrolled in Q3 2021:	256	302
Q3 2021 completion rate (1+ instrument):	6.6%	9.4%
Q3 2021 completion rate (all instruments):	5.5%	7.5%

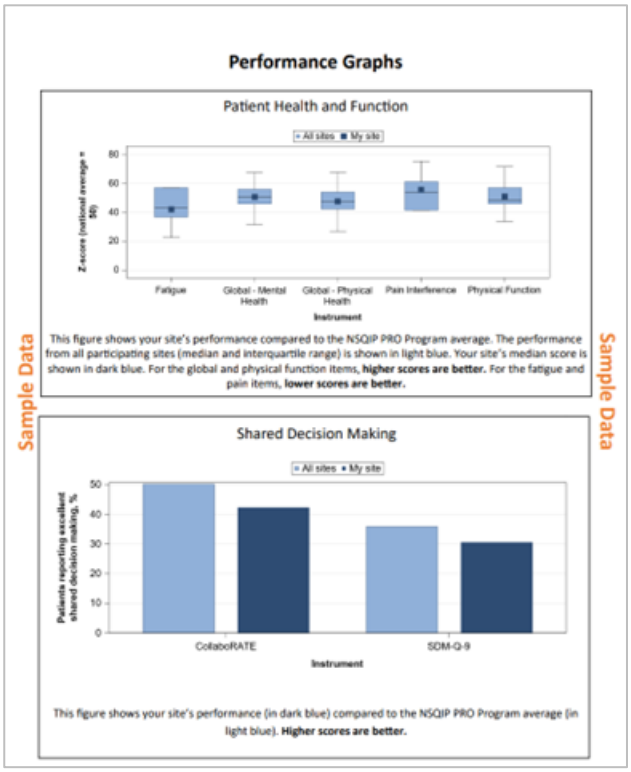
Patient Enrollment and Responses Over Time

Monthly Patient Enrollment

Monthly Response Rates

Sample Data

Sample Data



Performance Graphs

Patient Health and Function

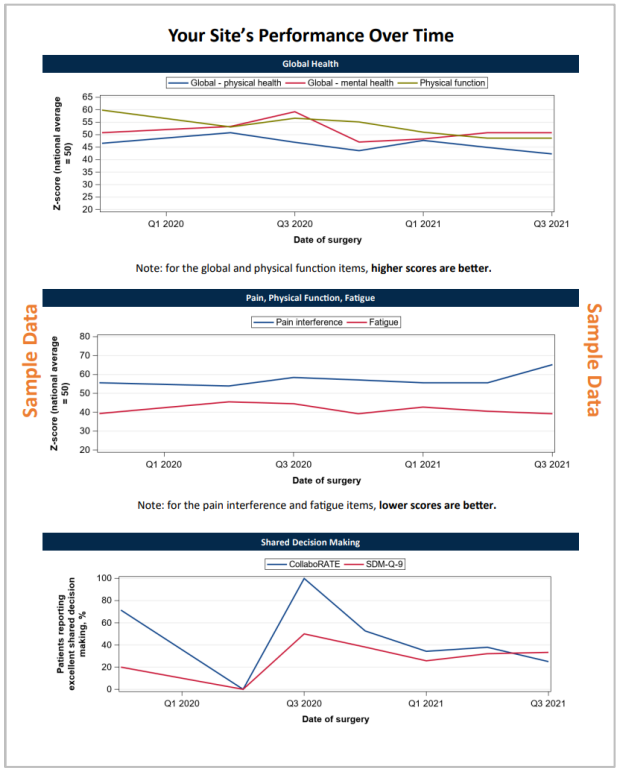
This figure shows your site's performance compared to the NSQIP PRO Program average. The performance from all participating sites (median and interquartile range) is shown in light blue. Your site's median score is shown in dark blue. For the global and physical function items, **higher scores are better.** For the fatigue and pain items, **lower scores are better.**

Shared Decision Making

This figure shows your site's performance (in dark blue) compared to the NSQIP PRO Program average (in light blue). **Higher scores are better.**

Sample Data

Sample Data



Your Site's Performance Over Time

Global Health

Note: for the global and physical function items, **higher scores are better.**

Pain, Physical Function, Fatigue

Note: for the pain interference and fatigue items, **lower scores are better.**

Shared Decision Making

Sample Data

Sample Data

Appendix 4a, supplemental tables. Multivariable analysis of patient characteristics associated with response to PROMs.

	Odds Ratio (95% Confidence Interval)
Mode	
SMS text messaging	---
Email	2.20 (1.67-2.89)
Age, y	1.03 (1.028-1.032)
Female sex	1.19 (1.15-1.24)
Race	
White	---
Black	0.78 (0.70-0.86)
Asian	0.78 (0.68-0.90)
Other/Unknown	0.75 (0.67-0.84)
Hispanic ethnicity	0.78 (0.71-0.85)
Insurance	
Commercial	---
Medicare	0.98 (0.91-1.04)
Medicaid	0.83 (0.78-0.89)
Self-pay	0.59 (0.49-0.71)
Other	0.95 (0.81-1.12)
Body mass index class	
Underweight	0.79 (0.68-0.91)
Normal	---
Overweight	1.07 (1.04-1.11)
Class 1	1.11 (1.06-1.17)
Class 2	1.15 (1.09-1.22)
Class 3	1.16 (1.09-1.24)
ASA Classification	
1-2	1.28 (1.09-1.50)
3	1.15 (1.03-1.28)
4-5	---
Outpatient	0.95 (0.89-1.02)
Emergency operation	0.54 (0.29-1.01)
Did not arrive from home	0.77 (0.65-0.90)
Partially or totally dependent functional status	0.47 (0.39-0.56)
Current cigarette use	0.78 (0.75-0.81)
Diabetes	
IDDM	0.85 (0.79-0.91)
NIDDM	0.98 (0.92-1.03)
COPD	0.89 (0.82-0.97)
Acute or chronic heart failure	0.86 (0.76-0.96)
Disseminated cancer	0.88 (0.79-0.98)
Dialysis	0.63 (0.52-0.76)
Chronic immunosuppression	1.13 (1.05-1.20)
Bleeding diathesis	0.84 (0.73-0.96)
Preoperative SIRS or sepsis	0.62 (0.53-0.73)
Preoperative transfusion	0.55 (0.45-0.69)
Surgical specialty	
Cardiothoracic Surgery	1.16 (0.91-1.48)
General Surgery	---
Neurosurgery	1.05 (0.91-1.23)
Obstetrics and Gynecology	1.10 (0.98-1.23)
Orthopedic Surgery	1.07 (0.95-1.20)
Otorhinolaryngology	0.92 (0.73-1.15)
Plastic Surgery	1.15 (0.99-1.33)
Urology	1.11 (0.97-1.27)
Vascular Surgery	0.79 (0.67-0.94)

ASA: American Society of Anesthesiologists; IDDM: insulin-dependent diabetes mellitus; NIDDM: non-insulin-dependent diabetes mellitus; COPD: chronic obstructive pulmonary disease; SIRS: systemic inflammatory response syndrome

Appendix 4b, supplemental tables. Respondent demographics by mode in Q3-2022 and later.

	SMS Text Messaging (n=2803)	Email (n=22560)	*p*	Effect Size
Age, y, median (IQR)	65.3 (55.9-72.9)	64.5 (53.6-72.0)	<0.001	0.03
Female, n (%)	1651 (58.9)	13875 (61.5)	0.008	0.02
Race, n (%)			0.009	0.02
White	2208 (78.8)	17694 (78.4)		
Black	301 (10.7)	2747 (12.2)		
Asian	95 (3.4)	569 (2.5)		
Other	199 (7.1)	1550 (6.9)		
Hispanic ethnicity, n (%)	219 (7.8)	1142 (5.1)	<0.001	0.04
Insurance, n (%)			<0.001	0.03
Commercial	1206 (43.0)	10588 (46.9)		
Medicare	1316 (47.0)	10078 (44.7)		
Medicaid	164 (5.9)	1070 (4.7)		
Self-pay	31 (1.1)	176 (0.8)		
Other	86 (3.1)	648 (2.9)		

Appendix 4c, supplemental tables. Respondent characteristics in Q3-2022 and later compared to before.

	Before Q3-2022 (n=8479)	Q3-2022 and later (n=25363)	*p*	Effect Size
Mode, n (%)			<0.001	0.05
SMS text messaging	1267 (14.9)	2803 (11.1)		
Email	7212 (85.1)	22560 (88.9)		
Age, y, median (IQR)	65.5 (56.0-72.3)	64.6 (53.8-72.1)	<0.001	0.03
Female sex, n (%)	5114 (60.3)	15526 (61.2)	0.14	<0.01
Race, n (%)			<0.001	0.03
White	6900 (81.4)	19902 (78.5)		
Black	853 (10.1)	3048 (12.0)		
Asian	207 (2.4)	664 (2.6)		
Other	519 (6.1)	1749 (6.9)		
Hispanic ethnicity, n (%)	373 (4.4)	1361 (5.4)	<0.001	0.02
Insurance status, n (%)			<0.001	0.03
Commercial	3859 (45.5)	11794 (46.5)		
Medicare	4027 (47.5)	11394 (44.9)		
Medicaid	335 (4.0)	1234 (4.9)		
Self-pay	56 (0.7)	207 (0.8)		
Other	202 (2.4)	734 (2.9)		
Body mass index class, n (%)			0.03	0.02
Underweight	68 (0.8)	252 (1.0)		
Normal	1817 (21.4)	5287 (20.9)		
Overweight	2804 (33.1)	8147 (32.1)		
Class 1	2028 (23.9)	6165 (24.3)		
Class 2	1083 (12.9)	3269 (12.9)		
Class 3	669 (7.9)	2243 (8.8)		
ASA Classification, n (%)			0.43	<0.01
1-2	4072 (48.0)	12334 (48.6)		
3	4212 (49.7)	12411 (48.9)		
4-5	195 (2.3)	618 (2.4)		
Outpatient, n (%)	5013 (59.1)	16002 (63.1)	<0.001	0.04
Emergency operation, n (%)	5 (0.1)	16 (0.1)	1.00	<0.01
Arrived from home, n (%)	8398 (99.0)	25108 (99.0)	0.75	<0.01
Partially or totally dependent functional status, n (%)	62 (0.7)	230 (0.9)	0.14	<0.01
Current cigarette use, n (%)	701 (8.3)	2394 (9.4)	0.001	0.02
Hypertension requiring medication, n (%)	4458 (52.6)	13209 (52.1)	0.43	<0.01
Diabetes, n (%)			0.56	<0.01
IDDM	380 (4.5)	1099 (4.3)		
NIDDM	977 (11.5)	3020 (11.9)		
COPD, n (%)	246 (2.9)	846 (3.3)	0.05	0.01

	Before Q3-2022 (n=8479)	Q3-2022 and later (n=25363)	*p*	Effect Size
Acute or chronic heart failure, n (%)	189 (2.2)	710 (2.8)	0.004	0.02
Disseminated cancer, n (%)	158 (1.9)	476 (1.9)	0.96	<0.01
Dialysis, n (%)	29 (0.3)	119 (0.5)	0.13	<0.01
Chronic immunosuppressants, n (%)	392 (4.6)	1336 (5.3)	0.02	0.01
Bleeding diathesis, n (%)	223 (2.6)	622 (2.5)	0.38	<0.01
Ascites, n (%)	21 (0.3)	64 (0.3)	1.00	<0.01
Preoperative SIRS or sepsis, n (%)	113 (1.3)	357 (1.4)	0.63	<0.01
Preoperative transfusion, n (%)	29 (0.3)	52 (0.2)	0.03	0.01
Ventilator assistance, n (%)	3 (0.04)	4 (0.02)	0.38	<0.01
Acute kidney injury, n (%)	3 (0.04)	12 (0.05)	0.77	<0.01
Surgical specialty, n (%)			<0.001	0.03
Cardiothoracic Surgery	139 (1.6)	430 (1.7)		
General Surgery	3178 (37.5)	9654 (38.1)		
Obstetrics and Gynecology	909 (10.7)	3156 (12.4)		
Neurosurgery	531 (6.3)	1408 (5.6)		
Orthopedic Surgery	2221 (26.2)	6181 (24.4)		
Otorhinolaryngology	174 (2.1)	630 (2.5)		
Plastic Surgery	260 (3.1)	827 (3.3)		
Urology	830 (9.8)	2466 (9.7)		
Vascular Surgery	237 (2.8)	611 (2.4)		
30-day Complications, n (%)				
Morbidity	388 (4.6)	1204 (4.8)	0.53	<0.01
Reoperation	168 (2.0)	445 (1.8)	0.17	<0.01
Readmission	325 (3.8)	943 (3.7)	0.62	<0.01

IQR: interquartile range; ASA: American Society of Anesthesiologists; IDDM: insulin-dependent diabetes mellitus; NIDDM: non-insulin-dependent diabetes mellitus; COPD: chronic obstructive pulmonary disease; SIRS: systemic inflammatory response syndrome