

Improving the Quality of Upper Urinary Tract Stone Surgery: External Validation of a Statewide Collaborative's Efforts to Reduce Emergency Department Visits After Ureteroscopy

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Study Need and Importance: The Reducing Operative Complications from Kidney Stones (ROCKS) program in the Michigan Urological Surgery Improvement Collaborative (MUSIC) was created to optimize ureteroscopy outcomes. Through data collection, distribution of reports, patient education, and standardization of medication, post-ureteroscopy emergency department (ED) visits in Michigan have declined. It is unclear if these declines were the result of MUSIC ROCKS initiatives or were due to national trends. We therefore sought to understand ED visit rates in Michigan compared to a national data set.

What We Found: From 2016 to 2021, the rate of post-ureteroscopy ED visits declined significantly in the MUSIC ROCKS registry (from 10.5% in 2016 to 6.9% in 2021) compared to a cohort in a large national data set, Clinformatics Data Mart (from 9.6% in 2016 to 10.0% in 2021). A visual representation of this decline can be seen in the Figure. The ED visit rate decline in MUSIC ROCKS outpaced national rates and provides evidence that systematic quality initiatives can improve urological care.

Limitations: Inherent differences in data collection and reporting techniques between a prospective registry (MUSIC ROCKS) and a retrospective claims database could have biased our results. However, by using the same methods within a Michigan-specific claims database we were able to limit the effect of these differences. There were also statistical differences in patient demographics be-

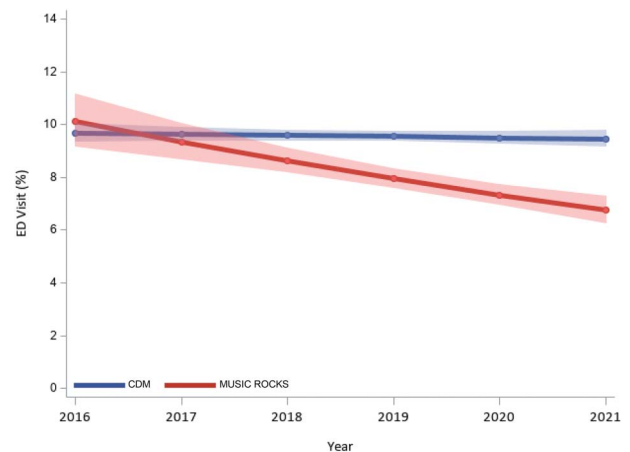


Figure. Predicted probability of post-ureteroscopy emergency department (ED) visit with 95% confidence limit bands by cohort after adjustment for age, gender, Charlson Comorbidity Index, and stent placement (difference in slopes: Wald χ^2 $P < .001$). CDM indicates Clinformatics Data Mart; MUSIC, Michigan Urological Surgery Improvement Collaborative; ROCKS, Reducing Operative Complications from Kidney Stones.

tween the cohorts, and despite adjustment in our model, the risk of confounding still exists.

Interpretation for Patient Care: The data presented within this manuscript provide the first external validation of the success of MUSIC ROCKS quality improvement efforts against an external source. This demonstrates that large, statewide quality improvement collaboratives have the ability to effect significant change in improving postoperative outcomes after kidney stone surgery.

Improving the Quality of Upper Urinary Tract Stone Surgery: External Validation of a Statewide Collaborative's Efforts to Reduce Emergency Department Visits After Ureteroscopy

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Purpose: The ROCKS (Reducing Operative Complications from Kidney Stones) program in MUSIC (Michigan Urological Surgery Improvement Collaborative) was created to optimize ureteroscopy outcomes. Through data collection, distribution of reports, patient education, and standardization of medication, post-ureteroscopy emergency department visits in Michigan have declined. It is unclear whether this is because of statewide quality efforts or due to national trends. We therefore sought to understand emergency department visit rates in Michigan compared to a national data set.

Materials and Methods: We compared the MUSIC ROCKS clinical registry in Michigan against a national cohort, Optum's de-identified Clinformatics Data Mart, from 2016-2021 (excluding Michigan). We identified patients who underwent ureteroscopy and the proportion who had a postoperative emergency department visit within 30 days. Emergency department rates were modeled over time, adjusting for age, gender, comorbidity, and ureteral stenting.

Results: We identified 24,688 patients in MUSIC ROCKS and 99,340 in the Clinformatics Data Mart database who underwent ureteroscopy. The risk-adjusted emergency department visit rate in MUSIC ROCKS significantly declined over the study period (10.5% in 2016 to 6.9% in 2021, $P < 0.001$) while the mean emergency department visit rate in the Clinformatics Data Mart cohort was 9.9% and did not change over time (9.6% in 2016 to 10% in 2021). Comparing emergency department visits between the cohorts, the MUSIC ROCKS rate significantly declined relative to the Clinformatics Data Mart ($P < 0.001$) over the study period.

Conclusions: Postoperative emergency department visit rates in Michigan have declined significantly after ureteroscopy since the establishment of MUSIC ROCKS. This decline outpaced national rates, providing evidence that systematic quality initiatives can improve urological care.

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Conflict of Interest: KRG: Boston Scientific, Olympus, Storz, Coloplast, Ambu; consultant; Boston Scientific, Coloplast, PCORI; investigator funding; CAD: Boston Scientific, Cook Medical; consultant; MT: Agency for Healthcare Research and Quality. MUSIC is funded by Blue Cross Blue Shield of Michigan, which provides salary support for KRG and CAD.

Ethics Statement: This study received Institutional Review Board approval (IRB No. HUM00054438).

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URETEROSCOPY (URS) is the most commonly performed surgical procedure for upper tract urinary stone disease in North America.¹ Technological

advancements, including improved ureteroscope design and optical capability and the widespread availability of lasers, have led to improved stone-

free rates over shock wave lithotripsy.² While URS is highly effective, 10% to 15% of patients experience unplanned health care encounters or emergency department (ED) visits within 30 days of surgery.^{3,4} Not only do these visits drive health care costs, but they also have implications for patients in terms of increased morbidity and lost productivity.³

In an effort to reduce ED visits after URS and shock wave lithotripsy, the Michigan Urological Surgery Improvement Collaborative (MUSIC) launched the Reducing Operative Complications from Kidney Stones (ROCKS) program. As MUSIC ROCKS has collected clinical outcomes data, distributed performance reports, and standardized patient education and postoperative pain control regimens, ED visit rates have declined in Michigan following URS.⁴⁻⁶ It is unclear whether this decline is due to the collaborative's quality-improvement efforts or reflects a broader secular trend.

We thus sought to externally validate our findings by identifying a cohort to serve as a representative comparison. Utilizing Optum's de-identified Clinformatics Data Mart (CDM) to understand national ED visit rates following URS, we compared these rates to those seen in MUSIC ROCKS. We hypothesize that the ED visit rates in Michigan will decline more rapidly than in other states due to these targeted quality-improvement efforts. It is our hope that validation of these efforts will provide evidence on the benefits of physician-led quality interventions and encourage the establishment of other quality initiatives to improve care for patients with urological disease.

METHODS

Data Sources and Study Population

MUSIC Rocks. MUSIC was established in 2011 with support from Blue Cross Blue Shield of Michigan (BCBSM) as a physician-led quality collaborative to improve cost efficiency and appropriateness of urological care in Michigan. In 2016, the ROCKS program was launched and is currently comprised of 38 urology practices across Michigan. MUSIC ROCKS maintains an all-payer, prospective clinical registry containing demographic and clinical data for patients undergoing URS or shock wave lithotripsy and their 60-day postoperative outcomes.^{7,8} Data abstraction is conducted at each practice by trained personnel. Data fidelity is ensured by data audits and site visits. Each practice has obtained exemption or approval by their respective Institutional Review Board.

We identified all patients aged 18 and older who underwent URS with or without stent placement for urinary stone disease from 2016 to 2021. We excluded bilateral and staged procedures.

CDM. The CDM contains de-identified administrative health claims for members of large commercial and Medicare

Advantage health plans. It captures all inpatient, outpatient, ED, and pharmacy claims for more than 45 million members and their dependents.⁹

We identified patients aged 18 and older who underwent URS for urinary stone disease between 2011 and 2021, using relevant Current Procedural Terminology (CPT) codes 52352, 52353, 52356, 52320, or 52325. This time frame was chosen so that there was a 5-year lead-in period prior to the launch of MUSIC ROCKS to establish a baseline. Staged URS, defined as claims with any URS 60 days prior or 30 days following the incident procedure, were excluded. Bilateral procedures (distinguished by modifier "50") were also excluded. To provide data regarding comorbid health conditions, beneficiaries were required to maintain continuous plan enrollment for at least 6 months prior and 1 month following URS. To avoid double counting, patients residing in the state of Michigan were excluded for the entire study period. The placement of a ureteral stent at the time of surgery was established by use of CPT 52356 or any other URS code when accompanied by CPT 52332.

MUSIC ROCKS Quality-improvement Interventions and

Timeline. During the initial 3 to 6 months after establishing the MUSIC ROCKS program, data collection and analysis commenced. Individual practices evaluated major reasons for ED visits and began grassroots efforts at the practice level to reduce ED visits. A steering committee of urologists with interest in urinary stone disease as well as patient advocates helped identify potential gaps in the quality of care that could lead to ED visits across the collaborative.^{4,10} Several broad areas for improvement were identified including patient education, postoperative pain optimization, and ureteral stent utilization.⁶ A timeline indicating when each intervention was introduced is depicted in Figure 1. Structured feedback was provided to urologists through triannual performance reports detailing individual practitioner ED visit rates as well as how these rates compared to their respective practice and the entire MUSIC ROCKS collaborative.

Definition of ED Visits

Our outcome of interest was an ED visit related to URS, which we defined in the MUSIC ROCKS registry as an ED visit within 30 days of surgery for one of the diagnoses listed in Supplemental Table 1 (<https://www.jurology.com>). These diagnoses are determined by abstractors reading through the patient-reported symptoms and discharge diagnoses of all post-URS ED visits. For the CDM cohort, we identified ED visits within 30 days of URS using relevant CPT codes and facility billing codes (Supplemental Table 2, <https://www.jurology.com>) related to ICD (International Statistical Classification of Diseases)-9/10 codes that mirrored the MUSIC ROCKS registry (Supplemental Table 3, <https://www.jurology.com>).

Statistical Analysis

We compared demographic and clinical variables including age, gender, baseline health status, and stent placement at the time of URS between the MUSIC ROCKS and CDM cohorts treated between 2016 and 2021 using Wilcoxon rank and χ^2 tests. To assess baseline

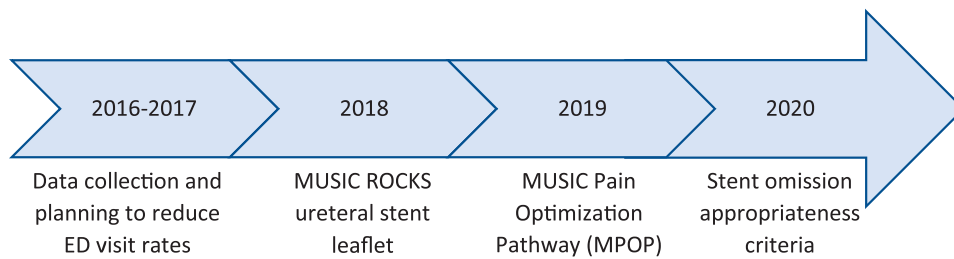


Figure 1. Timeline of Michigan Urological Surgery Improvement Collaborative (MUSIC) Reducing Operative Complications from Kidney Stones (ROCKS) interventions. ED indicates emergency department.

health status, we used the Charlson Comorbidity Index (CCI) score. A logistic regression model was used to compare the 30-day ED visit rates over time between MUSIC ROCKS and CDM. The outcome was 30-day ED visits, and the primary independent variables were cohort, year of URS as a continuous effect, and interaction between cohort and year of URS, and adjustment variables included continuous age, continuous CCI, and categorical gender and stent placement. The Wald χ^2 type 3 test of the interaction was reported to test the slope differences between the cohorts. Additionally, the slope within each cohort was compared to 0 to determine if there was significant change in the ED visit rate over time. Predicted probabilities with corresponding 95% confidence bands from the full model were plotted by year and cohort for the average patient. Since most quality-improvement interventions were targeted toward patient education and pain optimization, we hypothesized that the proportion of modifiable ED visits—defined as ED visits where the reason for visit was urinary frequency, hematuria, dysuria, flank pain, abdominal pain, and bladder pain—would decline within the MUSIC ROCKS cohort. We used Mantel-Haenszel χ^2 to compare modifiable visit proportions among the subset of ED visits over time in MUSIC ROCKS.

Sensitivity Analysis

Recognizing the obvious differences between claims data and a clinical registry, we sought to provide an internal control to validate the ED visit rates seen within MUSIC ROCKS. Less than 1% of the CDM cohort resided in Michigan, limiting use of CDM beneficiaries residing in Michigan as a viable data set for comparison. We partnered with the Michigan Value Collaborative (MVC), which is a collaborative quality initiative that includes 103 acute care hospitals and 40 physician organizations in Michigan supported by BCBSM. MVC supports statewide health care value improvement efforts with a multipayer, comprehensive administrative claims database comprised of Michigan residents insured by BCBSM commercial and Medicare Advantage plans, Blue Care Network health maintenance, and Medicare fee-for-service insurance. To construct a population like the CDM cohort, MVC used the same CPT and ICD-9/10 diagnosis and procedure codes to define a cohort of patients undergoing URS. ED visits were identified using a combination of bill and revenue codes. Patient factors were not available for adjustment.

The yearly ED visit rates from the MVC cohort were plotted with the MUSIC ROCKS and CDM cohort with 95% binomial confidence intervals. To test the rate of ED visits over time between the MUSIC ROCKS and MVC cohorts, a separate logistic regression model of ED visits with cohort, continuous year of URS, and the interaction of cohort and year as independent variables was used. The Wald χ^2 *P* value for the interaction is reported. Pairwise testing from the model of ED visit rate differences between cohorts for each year was performed with a Bonferroni multiple comparisons adjustment for the 6 comparisons; thus, *P* < .0083 was the threshold for significance.

All analyses were performed with SAS version 9.4. We performed 2-sided significance testing with a 5% type 1 error rate.

RESULTS

We identified a total of 24,688 patients within MUSIC ROCKS and 99,340 patients in the CDM cohort from 2016-2021 who underwent URS with urinary stone treatment. The CONSORT diagram of included CDM patients is found in Table 1. Table 2 shows the demographic and clinical data for each cohort. There were significant differences in the median age (58 vs 65 years, *P* < .001), male gender (49% vs 55%, *P* < .001), CCI (median 0 vs 1, *P* < .001), and stent use at time of URS (76% vs 89%, *P* < .001) between the MUSIC ROCKS and CDM cohorts, respectively.

The mean ED visit rate was 7.3% in MUSIC ROCKS and 9.9% in CDM. The ED visit rate observed in ROCKS declined from 10.5% in 2016 to 6.9% in 2021. After adjustment (Table 3), ROCKS had a model estimated 8% decreased odds of ED visits per year (OR=0.92 [95% CI: 0.89-0.95], *P* < .001). The rate in CDM remained statistically unchanged during the observation period from 9.6% in 2016 to 10% in 2021 (per-year OR=1.0 [95% CI: 0.98-1.0], *P* = .4). Adjusted predicted ED visit rates by cohort over time are presented in Figure 2 and demonstrate the significant difference in the rates over time between MUSIC ROCKS and CDM (*P* < .001).

As a sensitivity analysis, we evaluated 35,105 patients who underwent URS in the MVC cohort

Table 1. CONSORT Diagram for the Clinformatics Data Mart Ureteroscopy Cohort

Inclusion criteria	No. patients
Total outpatient URS from 2011-2021 (CPT codes 52352, 52353, 52356, 52320, 52325)	444,100
Unique URS by patient and surgery date	220,127
Incident URSs (ie, excluding staged URS within 60 d prior to or 30 d after)	179,366
Unilateral incident URSs (ie, exclude modifier "50")	177,680
Require 6 mo continuous enrollment prior to URS and 30 d after URS	146,812
Age \geq 18 y	146,063
Include only patients not from Michigan	144,758
Subset from 2016-2021	99,340

Abbreviations: CPT, Current Procedural Terminology; URS, ureteroscopy.

from 2016 to 2021. The overall ED visit rate was 7.4% in MVC and declined from 8.5% in 2016 to 6.8% in 2021 ($P < .001$). The slope test from the logistic model shows that the ED visit rates between MUSIC ROCKS and MVC were not significantly different (MUSIC ROCKS slope: OR per year=0.92, MVC slope: OR per year=0.94; $P = .3$; Figure 3). The ED visit rate of CDM from 2011-2016 is included to demonstrate relative stability of ED visits over the years leading up to the period evaluated in this study. Pairwise comparisons of the ED rates by year in MVC compared to MUSIC ROCKS were not significantly different for any year with multiple comparisons adjustment (all $P > .01$).

In MUSIC, among ED visits, modifiable ED visits were 35% of ED visits in 2016 and increased to 40% in 2020 but were 35% in 2021 ($P = .058$).

DISCUSSION

We found that the ED visit rate following URS in MUSIC ROCKS declined significantly from 2016 to 2021, whereas the CDM ED rate remained stable over this period. Sensitivity analysis comparing MUSIC ROCKS to claims data from the MVC largely paralleled our findings. Taken together, these data suggest that the statewide quality improvement facilitated by MUSIC ROCKS has driven a significant decline in the rate of 30-day ED visit after URS.

The greatest magnitude of ED visit rate decline in MUSIC ROCKS occurred in the first 2 years of the study. We hypothesize that this is due to identification of practice-level quality gaps and local grassroots efforts to mitigate ED visits in the early years of the collaborative. Interestingly, the rate of modifiable ED visits did not change over the study period. We feel that this is due to other ongoing quality-improvement efforts not detailed in this manuscript such as increased preoperative urine testing, which likely impacted the rate of infectious nonmodifiable ED visits.

Table 2. Population Descriptions of Included Patients in the Clinformatics Data Mart Database^a and the MUSIC ROCKS Registry

	CDM	MUSIC ROCKS	P value
Total patients	99,340	24,688	
Age, median (IQR), y	65 (52-73)	58 (45-68)	$< .001^b$
Male gender, No. (%)	55,064 (55)	12,009 (49)	$< .001^c$
Charlson Comorbidity Index, median (IQR)	1 (0-3)	0 (0-1)	$< .001^b$
Charlson Comorbidity Index, No. (%)			$< .001^d$
0	35,881 (36)	17,132 (69)	
1	20,405 (21)	4,164 (17)	
2	13,594 (14)	1,952 (7.9)	
3	9,333 (9.4)	791 (3.2)	
4	5,826 (5.9)	262 (1.1)	
5+	14,301 (14)	382 (1.6)	
Stent placement rate, No. (%)	88,025 (89)	18,683 (76)	$< .001^c$

Abbreviations: CDM, Clinformatics Data Mart; IQR, interquartile range; MUSIC, Michigan Urological Surgery Improvement Collaborative; ROCKS, Reducing Operative Complications from Kidney Stones.

^a Includes years 2016-2021.

^b Wilcoxon rank test.

^c χ^2 test.

^d Mantel-Haenszel χ^2 test.

To our knowledge, this is the first report of statewide quality-improvement initiatives leading to a decline in unplanned health care encounters after URS. Similar success has been demonstrated in other MUSIC initiatives, such as increased use of active surveillance for low-risk prostate cancer.¹¹ Outside of urology, the Michigan Arthroplasty Registry Collaborative Quality Initiative decreased need for transfusion after total hip arthroplasty through provider feedback, discussing conservative transfusion practices, and recommending intraoperative use of tranexamic acid.¹² Additionally, the Michigan Surgical Quality Collaborative reported a decline in surgical site infections from 6.7% to 3.9% through creation of a perioperative care bundle.^{13,14}

Our efforts to decrease ED visits in MUSIC ROCKS included distribution of provider performance reports, standardized patient education, and postoperative pain optimization. One could argue that another factor at play was the so-called Hawthorne effect, often described as behavior change in a population due to knowledge they are being observed. However, we would suggest that this intentional feedback loop of provider reports and discussion cultivated such behavior and was associated with positive results. Other studies have shown that feedback reporting is key to effecting change in provider behavior and patient outcomes.¹⁵ Hiller et al collected data on post-URS outcomes and found that stent use increased ED visits, thus inspiring initiatives on reducing stent use after URS, which in turn have led to fewer ED visits.^{4,6} Moreover, efforts targeting postoperative pain control in the MUSIC ROCKS collaborative have led to a reduction in opiate prescribing while

Table 3. Odds Ratio Estimates of Emergency Department Visits From a Multivariable Model

Effect	Point estimate	95% Wald confidence limits		Wald χ^2 P value
Age (per 5-y increase)	0.96	0.95	0.97	< .001
Male vs female gender	0.79	0.76	0.82	< .001
Charlson Comorbidity Index (per 1-unit increase)	1.11	1.10	1.12	< .001
Stented vs not stented after ureteroscopy	1.34	1.26	1.42	< .001
Cohort * y				< .001
CDM: per y increase	1.0	0.98	1.01	.4
MUSIC ROCKS: per y increase	0.92	0.89	0.95	< .001

Abbreviations: CDM, Clinformatics Data Mart; MUSIC, Michigan Urological Surgery Improvement Collaborative; ROCKS, Reducing Operative Complications from Kidney Stones.

overall ED visit rates continued to decline.⁵ Finally, the importance of preoperative patient education cannot be understated as it has been shown in other surgical fields to reduce postoperative unplanned health care encounters.¹⁶ The MUSIC ROCKS pain control optimization pathway protocol and patient education leaflets can be found on the MUSIC ROCKS website or by contacting the corresponding author for details.

Reducing unplanned encounters after urinary stone surgery is a key component of reducing overall health care costs. In 2014, it was estimated that an unplanned health care encounter after URS increased the overall episode cost by \$23,436.³ Moreover, the indirect costs related to lost productivity and work absences are substantial. Saigal et al reported that up to 30% of patients with urinary stones will miss work related to their

condition, with ambulatory care visits and hospitalizations resulting in 5.1 and 47.9 hours of missed work, respectively.¹⁷ Finally, the often unmeasured impact of these encounters on patient-reported outcomes and satisfaction related to URS is an area of current interest and study.^{18,19}

While our findings are compelling, they must be viewed within the context of several limitations. First, we compared a prospective registry (MUSIC ROCKS) against a large claims database (CDM). The MUSIC registry is populated by abstractors at each individual practice and is vulnerable to possible incorrect data entry. Results of our sensitivity analysis using claims data (MVC) paralleled the 30-day ED visit decline seen in the MUSIC registry, supporting the fidelity of our data. A second limitation is the difference in cohort demographics. The CDM cohort included

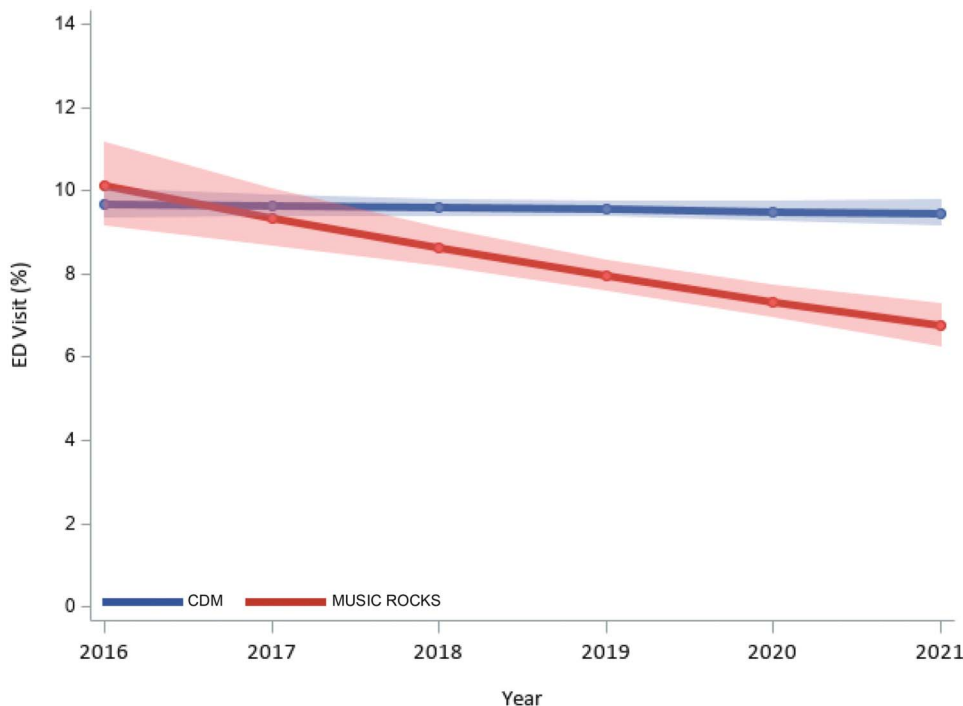


Figure 2. Predicted probability of postureteroscopy emergency department (ED) visit with 95% confidence limit bands by cohort after adjustment for age, gender, Charlson Comorbidity Index, and stent placement (difference in slopes: Wald χ^2 P < .001). CDM indicates Clinformatics Data Mart; MUSIC, Michigan Urological Surgery Improvement Collaborative; ROCKS, Reducing Operative Complications from Kidney Stones.

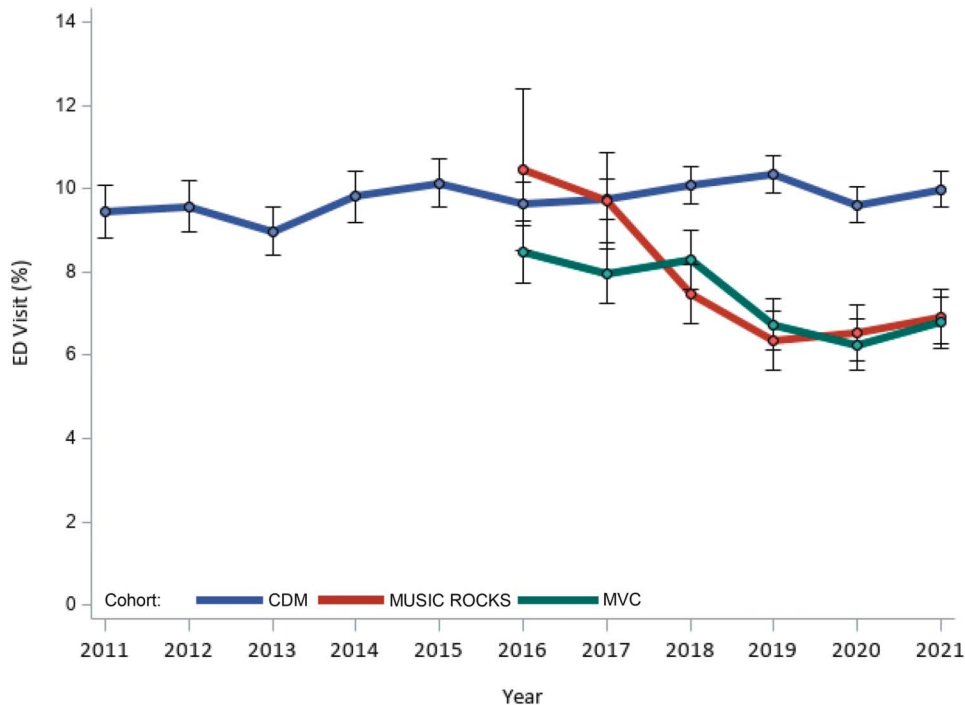


Figure 3. Unadjusted post-ureteroscopy emergency department (ED) visit rates by cohort with 95% binomial confidence intervals. The ED visit rate of the Clinformatics Data Mart (CDM) from 2011-2016 is included to demonstrate relative stability of ED visits over the years leading up to the period evaluated in this study. MUSIC indicates Michigan Urological Surgery Improvement Collaborative; MVC, Michigan Value Collaborative; ROCKS, Reducing Operative Complications from Kidney Stones.

older patients with greater degrees of comorbidity. While we adjusted for these factors in our multivariable model, bias toward the null hypothesis—that the ED visit rate decline in MUSIC ROCKS was due to unmeasured variables or demographic differences rather than quality efforts—still exists. Interestingly, prior retrospective work has not shown an association between age and comorbidity and ED visits after URS.^{5,20,21} This potential association should be further explored. Finally, it is possible that the decline in ED visit rates in MUSIC ROCKS are unrelated to ongoing quality-improvement efforts and instead are related to unmeasured confounding. However, other successful MUSIC ROCKS efforts such as opiate reduction after URS provided added proof of concept surrounding our quality-improvement methodology.⁵

Limitations notwithstanding, our data indicate that ED visits in the state of Michigan have declined significantly since the creation of MUSIC ROCKS. These findings suggest that dedicated physician-led quality efforts can provide tangible benefits for patients with urinary stone disease. We estimate that that 592 patients have avoided an ED visit in our collaborative since 2016, which translates to a direct cost savings of \$2.1 million (\$3,600 per patient) over the study period. Considering this, MUSIC has

expanded its model to several institutions outside the state in hopes of achieving similar benefits and provider engagement. Ongoing work to understand the implications of these efforts on patient-reported outcomes and satisfaction may provide additional justification for this model of collaborative quality improvement.

CONCLUSIONS

Since the establishment of the MUSIC ROCKS program, quality-improvement efforts have led to a decrease in post-URS ED visit rates in Michigan, whereas national ED visit rates remained unchanged. Our work provides evidence for the impact of physician-led collaborative quality efforts to improve care. Since the primary beneficiaries of such work are patients, it is our hope that other similar quality initiatives can be developed nationwide.

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