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Postoperative opioid analgesia impacts resource utilization in infants undergoing pyloromyotomy

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Abstract

BACKGROUND: Opioid analgesia is often avoided in infants undergoing pyloromyotomy. Previous studies highlight an association between opioid use and prolonged hospitalization after pyloromyotomy. However, the impact of opioid use on healthcare resource utilization cost is unknown. We hypothesized that use of opioids after pyloromyotomy is associated with increased resource utilization and costs.

METHODS: A retrospective cohort study was conducted identifying healthy infants <6 months with a diagnosis of pyloric stenosis who underwent pyloromyotomy from 2005–2015 among 47 children's hospitals using the Pediatric Health Information System database. Time of opioid

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Dr. Lakshmanan interpreted the data, and critically reviewed the manuscript for important intellectual content.

Dr. Song and Dr. Gong interpreted the data, and critically reviewed the manuscript for important intellectual content.

Dr. Friedlich interpreted the data, and critically reviewed the manuscript for important intellectual content.

Dr. Kelley-Quon conceptualized and designed the study, analyzed and interpreted the data, and critically reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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exposure was categorized as day of surgery alone (DOS), postoperative use alone, or combined DOS and postoperative use. Primary outcomes were the standardized unit cost, a proxy for resource utilization, billed charges to the patient/insurer, and hospital costs. A multivariable log-linear mixed-effects model was utilized to adjust for patient and hospital level factors.

RESULTS: Overall, 11,008 infants underwent pyloromyotomy with 2,842 (26%) receiving perioperative opioids. Most opioid use was confined to the day of surgery alone (n=2,158, 19.6%). Infants who received opioids on DOS and postoperatively exhibited 13% (95% CI: 7–20%, p-value <0.001) higher total resource utilization compared to infants who did not receive any opioids. Billed charges were 3% higher (95% CI: 0–5%, p-value=0.034) for infants receiving opioids isolated to the postoperative period alone and 6% higher (95% CI: 2–11%, p-value =0.004) for infants receiving opioids on the DOS and postoperatively.

CONCLUSIONS: Postoperative opioid use among infants who underwent pyloromyotomy was associated with increased resource utilization and costs.

Keywords

Pyloric stenosis; pyloromyotomy; opioid; resource utilization

INTRODUCTION

Hypertrophic pyloric stenosis (HPS) is a common diagnosis in otherwise healthy infants, affecting 1 to 3 in 1000 live births annually.¹ HPS occurs in a relatively discrete age group, is a non-painful pathology, is uniformly treated with pyloromyotomy, and complications are rare with over 95% recovering expectantly. While pain control is an essential part of postoperative recovery for all children undergoing surgery, infants undergoing pyloromyotomy rarely require highly potent analgesia after pyloromyotomy. Moreover, these patients are usually several weeks to a few months old and are particularly sensitive to opioids. Avoiding opioid in the perioperative period is generally recommended for infants undergoing pyloromyotomy to decrease the risk of complications such as postoperative apnea, respiratory depression, and metabolic disturbances.^{2,3}

Our group has previously found an association between postoperative opioid use and prolonged inpatient length of stay in infants undergoing pyloromyotomy for HPS.⁴ However, the impact of opioid use on healthcare resource utilization and costs associated with infants undergoing pyloromyotomy is not known. Using a large, nationally representative hospital administrative claims dataset, we hypothesized that opioid analgesia use after pyloromyotomy is associated with increased resource utilization and costs.

METHODS

Study Design, Participants, and Data Collection Procedures

A retrospective cohort study was performed using the Pediatric Health Information System® (PHIS) database. PHIS is a multicenter administrative database managed by the Children's Hospital Association (CHA; Lenexa, KS) and contains clinical and resource utilization data for both inpatient and outpatient encounters for free-standing children's hospitals across the

United States. Participating hospitals make available discharge data including demographic information as well as diagnoses and procedures coded with International Classification of Diseases, Clinical Modification (ICD-9-CM) codes. Additionally, detailed billing data, using the Clinical Transaction Classification (CTC) system, are available for medications, imaging studies, laboratory tests, and supplies for each patient encounter. All data is de-identified, and data quality is monitored by PHIS quarterly.⁵ Institutional Review Board approval and waiver of informed consent was obtained from the Children's Hospital of Los Angeles.

Infants <6 months with hypertrophic pyloric stenosis (ICD-9-CM 750.5) who underwent pyloromyotomy (ICD-9-CM 43.3) between 2005–2015 were identified. Patients with a complex chronic condition,^{6–8} those missing pharmacy, gender, race, and insurance data were excluded. Patient demographics included age, gender, race, ethnicity, and insurance status. Hospital factors included United States census region and total number of staffed beds as a proxy for hospital size.

Definition of Opioid Exposure

The principal exposure was defined as the use of any opioid medication during the patient's hospitalization, as defined by Womer et al.⁹ Opioid use was determined from available billing data which captures generic pharmacy codes. Opioid use was dichotomized as 'exposed' versus 'unexposed', and further stratified by period of perioperative exposure (day of surgery alone, postoperative alone or day of surgery and postoperative). Opioids received on the day of surgery were considered a day of surgery exposure. Postoperative exposure included any opioids prescribed one or more days following surgery. Medication dosing and frequency of administration are not captured by PHIS and therefore were not included in our analysis.

Definition of Outcomes

Our primary outcome of interest was in-hospital resource utilization. The PHIS database generates standardized costs for all billed items at PHIS participating hospitals so that resource utilization can be compared. Standardized unit costs are created from a Cost Master Index for each cost-to-charge (CTC) code and discharge year is determined by first calculating a cost for every encounter and CTC code. The cost is derived by multiplying the adjusted charges for the CTC code by the corresponding ratio of costs-to-charges (RCC) and dividing by the number of units. For every discharge year the median of these costs is determined for each hospital and CTC code. A median cost for a CTC code is determined using the median cost of each hospital within that CTC code and discharge year. In summary, the standardized unit cost is the median of all the hospital's medians. By using a standard unit cost for an item across all PHIS hospitals, differences in cost can be attributed to variation in volume. It is critical to note that this measure is not representative of the true hospital cost, but rather an intensity screener for resource utilization. Standardized unit costs included from six main billing groups including pharmacy, supplies, laboratory, imaging, clinical, and other (room and board). Standardized unit costs do not include professional fees. A standardized total cost for a patient encounter was calculated by adding up the six standardized costs. Hospital costs, represented as median estimated costs, are defined as

hospital expenses incurred by the provider to deliver the service per patient encounter. Billed charges are defined as those expenses that the hospital asks of the patient and/or insurer.

Statistical Analyses

Continuous variables were described using mean and standard deviation, and median and interquartile range. Proportions were used to describe categorical variables. Bivariate analysis was used to compare patient demographic and hospital-level data. Chi-square and Wilcoxon-Mann-Whitney tests were used to analyze categorical and continuous. Distributions for continuous variables were assessed for normality by histograms and Q-Q plots.

Multivariable log-linear regression analysis with mixed-effects was used to determine estimates for opioid use and standardized costs of interest: clinical, imaging, laboratory, other, pharmacy, supply, and total. Mixed-effects modeling was employed to control for unmeasured hospital characteristics that may confound any associations. Covariates in the model included: sex, race, age, insurance status, hospital region and staffed beds. Race was included in adjusted models, however ethnicity was collected on observation or volunteered by the patient and in some cases applied to the patients' race. As such, adjustment for ethnicity was not included in the final log-linear models. Data were analyzed using SAS® software 9.4 (copyright © 2016 SAS Institute Inc., Cary, NC) and StataCorp (2017) *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LLC. A p-value <0.05 was considered statistically significant.

RESULTS

The final cohort included 11,008 infants who underwent pyloromyotomy from 47 hospitals across the United States (Figure 1). Overall, 2,842 (26%) infants were exposed to opioids during hospitalization and surgery for pyloric stenosis (Table 1). Infants exposed to opioids were older (39 days vs. 35 days, p-value<0.001), less likely to have private insurance (39% vs 41%, $P=0.001$), and more frequently exposed to opioids in hospitals located in the southern United States (50% vs. 36%, $P<0.001$). Among infants receiving opioids, perioperative timing of opioid administration was as follows: DOS alone (n=2,158, 19.6%), postoperative use alone (n=466, 4.2%), and both DOS and postoperative use (n=130, 1.2%). Use of opioids before surgery alone was infrequent (n=88, 0.79%), and these infants were omitted from further analysis.

On unadjusted bivariate analysis of median standardized cost, infants exposed to opioids on DOS alone exhibited decreased median standardized costs of \$6,480 (IQR: \$5,390-\$8,174) compared to infants with no opioid use during hospitalization, \$6,811 (IQR: \$5,582-\$8,488, p-value <0.001) (Table 2). Conversely, infants who received opioids postoperatively alone did not differ significantly in their standardized costs, \$6,928 (IQR: \$5,571-\$8,716), p-value=0.995) while infants exposed to opioids on DOS and postoperatively had significantly increased median standardized costs, \$7,492 (\$5,784-\$9,578, p-value=0.014).

On unadjusted bivariate analysis of median charges and costs, infants exposed to opioids on DOS alone exhibited decreased median charges billed to the patient and/or insurer of

\$17,553 (IQR: \$13,609–\$22,033), p -value <0.001 , and decreased estimated median costs of \$6,401 (IQR: \$5,108–\$7,980, p -value <0.001), compared to infants with no opioid use during hospitalization, \$17,805 (IQR: \$14,352–\$22,451) and 6,595 (IQR: \$5,471–8,043), respectively (Table 3). Conversely, infants who received opioids postoperatively alone did not differ significantly in their median billed charges or hospital costs, while infants exposed to opioids on DOS and postoperatively had significantly decreased median billed charges to the patient and/or insurer of \$15,624 (IQR: \$11,480–21,220, p -value=0.001) and decreased median estimated cost to the hospital of \$6,432 (IQR: \$5,246–\$8,742, p -value=0.01).

In adjusted analyses, pharmacy resource utilization was significantly higher in opioid exposed infants regardless of perioperative timing, when compared to unexposed infants (Table 4). Adjusted models demonstrated geometric mean pharmacy utilization was 13% higher (95% CI: 10%–16% $P<0.001$) for infants receiving opioids at any point during hospitalization. Pharmacy resource utilization was 46% higher in infants exposed to opioids on both DOS and post-operatively (95% CI: 31%–62% p -value <0.001). For infants only exposed to opioids postoperatively, total resource utilization was 3% higher (95% CI: 0%–6%, p -value =0.048). Infants who received opioids postoperatively incurred 5% higher room and board costs (95% CI: 2%–8% p -value <0.01), as did the infants exposed on DOS and post-operatively, where room and board resource utilization costs were 13% higher than unexposed infants (95% CI: 7%, 20%, p -value <0.0001). Overall, infants who received opioids on DOS and postoperatively exhibited 13% (95% CI: 7%–20%, p -value <0.001) increased total resource utilization, primarily mediated by pharmacy and room and board resource utilization costs.

On adjusted analysis, overall median billed charges and median estimated costs were not significantly different between opioids exposed and unexposed infants. Among infants exposed to any opioid during their hospitalization, only pharmacy charges were 12% higher (95% CI: 9%–15%, $p<0.0001$) than unexposed infants (Table 5). Pharmacy charges remained significantly higher for infants who received any opioids in the perioperative period compared to unexposed (Table 5). Billed charges to the patient and/or insurer were 3% higher (95% CI: 0%, 5%, $p<0.05$) for infants receiving opioid isolated to the postoperative period and 6% higher (95% CI: 2%, 11%, $p<0.005$) in the DOS and postoperative group. Estimated costs to the hospital in the group who received any opioid during the perioperative period were not significantly different than the unexposed group.

DISCUSSION

This large retrospective cohort study of infants undergoing pyloromyotomy demonstrated notable variability in opioid use and associated costs across hospitals in the United States. Our findings suggest that opioids administered after pyloromyotomy resulted in increased overall resource utilization. Not surprisingly, pharmacy resource utilization was increased for infants receiving opioids regardless of time of exposure. Overall estimated costs did not significantly differ between administration timing groups, but billed charges to patients and/or insurers were increased among postoperative opioid groups. These results suggest that postoperative opioid administration is associated with increased resource utilization and billed charges.

To our knowledge, this is the first large cohort study examining the influence of perioperative opioid analgesia on healthcare resource use and cost in infants undergoing pyloromyotomy. Our group previously found that opioid use confined to DOS alone was associated with a shorter length of stay (and any other opioid exposure conversely associated with a longer length of stay) after pyloromyotomy. This prior study suggests that avoidance of opioids in the postoperative period after pyloromyotomy may help limit complications.⁴ Our current study aligns with our previous results, as infants that received opioid analgesics at any time other than the DOS alone had higher room and board costs. On bivariate analysis, opioids given on the DOS alone were associated with lower overall resource utilization, but after controlling for patient factors we found this association to be no longer significant. Ultimately, these results raise more questions into the clinical benefit (and potential harm) related to opioid use in this vulnerable patient population.

While we found that postoperative opioid analgesics after pyloromyotomy were associated with increased resource utilization costs, surprisingly, hospital costs were not significantly increased. Instead billed charges to the patients were significantly higher indicating that either the patient or the patient's insurance company or both were responsible for remunerating increased utilization costs associated with postoperative opioid use, not the hospital. One explanation of this finding is that hospitals bill the patient for the quantifiable standardized cost variables found in the PHIS dataset, like medications, diagnostic tests, and supplies, while also maintaining a high proportion of fixed operating costs to administer services for a variety of common patient admissions and procedures.^{10,11} Our results may also simply be reflective of the general trend of increased in overall healthcare costs over time associated with increasing volume of care, newer treatments, and technologies leading hospitals to increased charges to deliver services at a rate more substantially than hospital costs.^{12–15} These findings support judicious use and timing of opioid administration, as postoperative opioid use after pyloromyotomy increase resource costs and can impose financial burden to the patient.

While opioid minimization as part of enhanced recovery after surgery (ERAS) protocols have been associated with improved patient outcomes and resource utilization in adult patients, similar protocols are still emerging for pediatric surgical conditions.^{16–21} Multimodal analgesic strategies can often rely on newer analgesics like intravenous acetaminophen – which raises concerns regarding cost effectiveness.²² However, opioid sparing techniques may ultimately result in cost-savings by decreasing average morphine requirements, length of stay, and readmission rates.^{20,21,23} Our study adds to the increasing volume of literature that has emerged regarding value-based care in pediatric surgical patients.²⁴ Active surveillance and limitation of opioid use may prove to be important quality metrics when assessing our care of children with HPS and many other common surgical conditions.

This study is strengthened by use of cost-to-charge adjustments, which control for wide regional variations in hospital costs and accounts for inflation – ultimately allowing for a more appropriate comparison of resource use between hospitals. However, our data also have several limitations unique to performing a retrospective analysis of a large administrative claims database. The Children's Hospital Association does not require all

hospitals to uniformly report cost-to-charge data to PHIS and infants missing complete cost-to-charge data were omitted from the present study. While a large number of infants were excluded for this reason, there were not large differences between included and excluded groups and therefore infants with missing cost-to-charge data were likely missing at random, and therefore less likely to introduce bias into the present analysis. Coding errors may also account for omission or incorrectly represented data for both clinical data and hospital charges. The PHIS database also does not discriminate total daily dosing of opioids and only a binary response of administration is captured, thereby limiting evaluation of a dose-dependent relationship between opioid use and resource utilization, costs and charges. In addition, the association between opioid use and increased resource utilization could be a proxy of delayed return of gastric function postoperatively, as infants with self-limited gastroparesis or an incomplete myotomy may get morphine due to increased fussiness in response to delayed recovery. When reviewing the rates of postoperative vomiting after pyloromyotomy, which may preclude administering oral pain medications, emesis is quite common, occurring in 30–90% of infants.^{25–27} However, timing to full enteral feedings is generally within one day after surgery. Based on these observations, it is reasonable to suggest that if patients truly cannot tolerate anything by mouth, including pain medication like Tylenol, then the rate of postoperative opioid use like morphine would be much higher than the 5% prevalence found in our study. Regarding an incomplete myotomy, this complication occurs at a seemingly negligible incidence in open procedures, and for laparoscopic pyloromyotomy, the incidence is 1–2%,^{28,29} suggesting that the impact of this surgical complication on medication usage is less likely. This study was also limited by our inability to differentiate between laparoscopic versus open pyloromyotomy as these are not distinguished in ICD-9-CM. This represents an important potential confounder, as a previous multicenter randomized trial found that the laparoscopic approach resulted in shorter hospital stay and inpatient ward costs.³⁰ While we cannot ascertain the proportion of those infants undergoing a laparoscopic procedure, laparoscopic pyloromyotomy has progressively become the preferred approach among most children's hospitals and likely represents the majority of this modern cohort.^{29,31,32} Furthermore, both approaches are not associated with considerable anesthetic need.^{25,33,34}

CONCLUSION

Among children's hospitals in the United States, postoperative opioid analgesia used in infants undergoing pyloromyotomy was associated with increased resource utilization and costs. While most infants undergoing pyloromyotomy do not require opioid pain control, maximizing non-opioid analgesic therapies may save resources and dollars for patients, hospitals and insurers.

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Abbreviations:

PHIS	Pediatric Health Information System
ICD	International Classification of Diseases
CM	Clinical Modification

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- Postoperative opioid use in infants undergoing pyloromyotomy is associated with increased resource utilization and charges billed to patients and/or insurers
- Increased charges are primarily mediated by increased pharmacy and room and board costs.
- Maximizing non-opioid analgesic use in infants undergoing pyloromyotomy may translate to dollars and resources saved for patients, hospitals and insurers.

Figure 1.
Flow diagram of cohort selection.

Table 1.

Hospital characteristics and patient demographics of infants that underwent pyloromyotomy.

	Overall n = 11,008	Opioid Exposed n = 2,842	Opioid Unexposed n = 8,166	p-value
Patient age, days	36.3(16.8)	38.6(18.5)	35.5(16.1)	<0.001
Sex				
Female	1,909(17.3)	470(16.5)	1,439(17.6)	0.189
Male	9,099 (82.7)	2,372 (83.5)	6,727 (82.4)	
Ethnicity				
Hispanic or Latino	2,949 (26.8)	724 (25.5)	2,225 (27.3)	<0.001
Not Hispanic or Latino	4,914(44.6)	1,421 (50.0)	3,493 (42.7)	
Unknown	3,145 (28.6)	697 (24.5)	2,448 (30.0)	
Race				
White	8,485 (77.1)	2,266 (79.7)	6,219(76.2)	<0.001
Black	906 (8.2)	177 (6.2)	729 (8.9)	
Asian	85 (0.8)	20 (0.7)	65 (0.8)	
American Indian/Alaskan				
Native/Native Hawaiian/Pacific	95 (0.9)	25 (0.9)	70 (0.9)	
Islander				
Other	1,437(13.1)	354(12.5)	1,083(13.3)	
Insurance				
Private	2,383(21.65)	607(21.4)	1,776(21.8)	0.301
Public	4,616(41.9)	1,166(41.0)	3,450 (42.3)	
Other	4,009 (36.42)	1,069 (37.6)	2,940 (36.0)	
Hospital Region				
Midwest	2,765 (25.1)	500(17.6)	2,265 (27.7)	<0.001
Northeast	1,249(11.4)	138 (4.9)	1,111(13.6)	
South	4,388 (39.9)	1,464(51.5)	2,924 (35.8)	
West	2,606 (23.7)	740 (26.0)	1,866(22.9)	
Number of Hospital Staffed Beds	346(136.3)	331 (135.2)	352(136.2)	<0.001

Data presented as n (%) or mean ($\pm$ standard deviation). Chi-square tests and Mann-Whitney U used to compare categorical and continuous variables, respectively.

Table 2:Standardized costs^{*,**} by perioperative period

	No Opioid Use (Ref) n = 8,166	Day of Surgery Use n = 2,158	p-value	Postoperative Use n = 466	p-value	DOS + Post-op Use n = 130	p-value
Clinical	402 (189–954)	373 (174–744)	<0.001	333 (136–778)	<0.001	374(164–743)	1.000
Imaging	158(143–205)	157(143–203)	1.000	149(140–177)	<0.001	154(143–212)	1.000
Laboratory	130(81–220)	130 (80–209)	0.731	131 (84–218)	1.000	156 (93–261)	0.056
Other	5,054(4,087–6,314)	4,805 (3,874–5,964)	<0.001	5,066 (4,098–6,472)	1.000	5,614(4,330–7,342)	0.006
Pharmacy	152(98–229)	172(113–253)	<0.001	190(123–285)	0.001	221 (162–352)	<0.001
Supply	411(203–740)	495 (255–772)	<0.001	515(279–874)	<0.001	445 (238–760)	1.000
Total	6,811 (5,582–8,488)	6,480(5,390–8,175)	<0.001	6,928 (5,571–8,716)	0.995	7,492 (5,784–9,578)	0.014

* Median (Interquartile range, IQR) reported in U.S. dollars, adjusted for inflation using the consumer price index (CPI) for medical care in 2015. Dunn's pairwise comparisons to opioid unexposed patients, with Bonferroni correction.

** Standardized unit costs are a proxy for resource utilization and should not be interpreted as the true charge to a patient, or true cost to a hospital to provide services.

DOS = Day of Surgery

Table 3:

Charges and estimated cost* by opioid exposure during the perioperative period

	No Opioid Use (Ref) n = 8,166	Day of Surgery Use n = 2,158	p-value	Postoperative Use n = 466	p-value	DOS + Post-op Use n = 130	p-value
Clinical Charges	612(3,334–1,130)	540 (275–1091)	<0.001	552(235–1258)	0.279	457(195–965)	0.010
Imaging Charges	681 (511–879)	704 (509–865)	0.323	624(456–812)	<0.001	544 (430–769)	<0.001
Laboratory Charges	556 (327–956)	552(331–930)	1.000	553(316–1031)	1.000	533(316–1,063)	1.000
Other Charges**	13,169(9,869–17,077)	12,606(8,909–16,480)	<0.001	12,327(8,879–17,043)	0.049	12,049(7,821–15,855)	0.007
Pharmacy Charges	624(342–1,021)	668(402–1,117)	<0.001	764(466–1,337)	<0.001	748(470–1,027)	0.021
Supply Charges	1,109(433–2,236)	1,257(625–2,090)	0.001	1,230 (533–2,240)	0.201	1,058(505–18,145)	0.880
Billed Charges	17,805(14,352–22,451)	17,553 (13,609–22,033)	<0.001	17,685 (13,474–22,670)	0.997	15,624(11,480–21,220)	0.001
Estimated Cost	6,595 (5,471–8,043)	6,401 (5,108–7,980)	<0.001	6,736 (5,430–8,522)	0.279	6,432 (5,246–8,742)	0.010

* Median (Interquartile Range, IQR) reported in U.S. dollars, adjusted for inflation using the consumer price index (CPI) for medical care in 2015. Dunn's pairwise comparisons to opioid unexposed patients, with Bonferroni correction.

** Principally room and board charges/resource utilization.

DOS = Day of Surgery

Table 4.

Comparison of standardized costs* by opioid use versus no opioid use

	Any Opioid Use	
	Coef. [95% CI]	p-value
Clinical	0.94 [0.89,0.99]	0.028
Imaging	0.99 [0.97,1.01]	0.224
Laboratory	0.97 [0.94,1.00]	0.087
Other (room & board)	1.01 [0.99,1.02]	0.207
Pharmacy	1.13 [1.10,1.16]	<0.001
Supply	1.04 [1.00,1.08]	0.069
Total	1.01 [0.99,1.02]	0.474
	Day of Surgery Opioid Use	
	Coef. [95% CI]	p-value
Clinical	0.95 [0.90,1.02]	0.154
Imaging	1.00 [0.98,1.02]	0.992
Laboratory	0.96 [0.93,1.00]	0.043
Other (room & board)	0.99 [0.98,1.01]	0.351
Pharmacy	1.11 [1.08,1.15]	<0.001
Supply	1.02 [0.98,1.06]	0.337
Total	0.99 [0.98,1.01]	0.328
	Postoperative Opioid Use	
	Coef. [95% CI]	p-value
Clinical	0.87 [0.77,0.97]	0.017
Imaging	0.92 [0.88,0.96]	<0.001
Laboratory	0.98 [0.92,1.04]	0.458
Other (room & board)	1.05 [1.02,1.08]	0.001
Pharmacy	1.13 [1.06,1.19]	<0.001
Supply	1.04 [0.96,1.12]	0.312
Total	1.03 [1.00,1.06]	0.048
	Day of Surgery & Postoperative Opioid Use	
	Coef. [95% CI]	p-value
Clinical	0.85 [0.69,1.05]	0.137
Imaging	1.00 [0.92,1.09]	0.977
Laboratory	1.06 [0.94,1.19]	0.373
Other (room & board)	1.13 [1.07,1.20]	<0.001
Pharmacy	1.46 [1.31,1.62]	<0.001
Supply	1.26 [1.09,1.45]	0.001
Total	1.13 [1.07,1.20]	<0.001

Models were controlled for gender, race, patient age, insurance status, hospital size, hospital region, and year of surgery.

* Values expressed as geometric mean standardized costs representing overall healthcare utilization

CI = Confidence Interval

Table 5.

Comparison of patient charges and hospital cost* by opioid use versus no opioid use

	Any Opioid Use	
	Coef. [95% CI]	p-value
Clinical Charges	1.01 [0.95,1.06]	0.842
Imaging Charges	0.99 [0.96,1.01]	0.339
Laboratory Charges	0.97 [0.94,1.00]	0.063
Other Charges	1.01 [0.99,1.02]	0.3394
Pharmacy Charges	1.12 [1.09,1.15]	<0.001
Supply Charges	1.05 [1.01,1.10]	0.019
Billed Charges	1.01 [1.00,1.02]	0.098
Estimated Cost	1.00 [0.97,1.02]	0.719
	Day of Surgery Opioid Use	
	Coef. [95% CI]	p-value
Clinical Charges	1.02 [0.96,1.08]	0.545
Imaging Charges	1.00 [0.97,1.03]	0.904
Laboratory Charges	0.97 [0.93,1.00]	0.063
Other Charges	1.00 [0.98,1.01]	0.665
Pharmacy Charges	1.11 [1.08,1.15]	<0.001
Supply Charges	1.03 [0.98,1.08]	0.198
Billed Charges	1.00 [0.99,1.02]	0.677
Estimated Cost	1.00 [0.97,1.02]	0.788
	Postoperative Opioid Use	
	Coef. [95% CI]	p-value
Clinical Charges	0.98 [0.88,1.09]	0.707
Imaging Charges	0.91 [0.86,0.96]	<0.001
Laboratory Charges	0.95 [0.89,1.01]	0.117
Other Charges	1.03 [1.01,1.06]	0.0134
Pharmacy Charges	1.08 [1.02,1.14]	0.005
Supply Charges	1.06 [0.98,1.16]	0.155
Billed Charges	1.03 [1.00,1.05]	0.034
Estimated Cost	0.98 [0.93,1.03]	0.371
	Day of Surgery & Postoperative Opioid Use	
	Coef. [95% CI]	p-value
Clinical Charges	0.94 [0.77,1.15]	0.552
Imaging Charges	1.01 [0.92,1.12]	0.827
Laboratory Charges	1.05 [0.93,1.18]	0.424
Other Charges	1.06 [1.01,1.11]	0.010
Pharmacy Charges	1.41 [1.28,1.55]	<0.001
Supply Charges	1.29 [1.10,1.51]	0.002
Billed Charges	1.06 [1.02,1.11]	0.004
Estimated Cost	1.05 [0.96,1.15]	0.286

Models were controlled for gender, race, patient age, insurance status, hospital size, hospital region, and year of surgery.

* Values expressed as geometric mean

CI = Confidence Interval

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