Association of an Enhanced Recovery After Cesarean Surgery Protocol With Postpartum Opioid Utilization: Analysis of a Quality Improvement Project

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ABSTRACT

Introduction: Research has shown that 1 of every 50 to 300 patients can develop chronic opioid use following treatment of acute pain, including after cesarean birth. Our hospital identified that our post-cesarean patients utilized high doses of systemic opioids. This study sought to determine whether implementation of a standardized enhanced recovery after cesarean surgery (ERAS) protocol decreased opioid utilization following cesarean birth.

Methods: An evidence-based ERAS protocol was created and implemented. This protocol included intrathecal morphine and a standardized approach to all phases of perioperative care for both scheduled and unscheduled cesarean deliveries. A before-and-after analysis compared oral morphine milligram equivalents (MME) for 9 months prior to and 9 months after implementation. People with chronic opioid use for any indication or postoperative intubation were excluded. The primary outcome was the cumulative MME utilization in the first 48 hours postoperatively. MME utilization and pain scores at other time points were compared.

Results: Patients who underwent cesarean birth prior to implementation of the ERAS protocol (pre-ERAS) (n = 973) and after implementation (post-ERAS) (n = 1025) were included. The median cumulative opioid dose in the first 48 hours post-cesarean was 122 MME (interquartile range [IQR] 80-164) pre-ERAS compared to 8 MME (IQR 0-48) post-ERAS ($P < 0.001$). The median cumulative MME was higher in the pre-ERAS period compared to the post-ERAS period for all time points assessed. The prevalence of pain scores >7 in the first 24 hours was decreased in the post-ERAS period as was the percentage of patients requiring any opioids.

Conclusions: An ERAS protocol for cesarean birth including intrathecal morphine was associated with a 93.8% reduction in cumulative opioid dose by MME and should be considered by all hospitals that offer obstetric services.

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INTRODUCTION

Over 30% of births in the United States occur via cesarean delivery. One of every 50 to 300 patients can develop chronic opioid use following treatment of acute pain, including after cesarean.[1] Accordingly, multimodal approaches endorsed by the enhanced recovery after surgery "ERAS" Society and the Society of Obstetric Anesthesia and Perinatology emphasize nonopioid analgesia.[2-6] ERAS refers to a patient-centered, evidence-based, multimodal, and multidisciplinary approach to postoperative recovery with a goal of reducing pain and facilitating recovery.

Our hospital identified that our post-cesarean patients utilized high doses of systemic opioids.[7] Our prior strategy to reduce opioid utilization with scheduled acetaminophen and nonsteroidal anti-inflammatory drugs (NSAID) reduced opioid utilization by approximately 20%, but opioid utilization remained high.[8] We next implemented a post-cesarean ERAS protocol. The analysis presented here evaluated the association of this protocol with post-cesarean opioid utilization. Our hypothesis was that post-cesarean opioid utilization in the first 48 hours (calculated as morphine milligram equivalents [MME]) would decrease following implementation of the ERAS protocol.

MATERIALS AND METHODS

This project was reviewed by the Institutional Review Board at the University of Wisconsin-Madison and UnityPoint Health-Meriter and was deemed to meet requirements for a quality improvement project. UnityPoint Health-Meriter is the setting of the University of Wisconsin's obstetrical service. This quality improvement project is reported in accordance with the SQUIRE 2.0 and RECOvER checklists.[9,10] Here we report analysis of opioid utilization before and after implementation of this post-cesarean ERAS protocol at a single hospital.

A multidisciplinary committee convened in January 2020 to design an evidence-based enhanced recovery after cesarean surgery (ERAS) protocol. The committee consisted of representatives from every phase of prenatal, intrapartum, and postpartum care and included the disciplines indicated in Supplemental Table 1. Together, this group reviewed existing cesarean ERAS protocols and reviewed evidence for additional components considered.[2,3,6,11,12] The protocol had an implementation date of June 29, 2021. However, 1 portion of the protocol – intrathecal morphine – was implemented early on March 2, 2021, for the following reasons: (1) the need for intrathecal morphine was great given the previously identified high post-cesarean opioid utilization, (2) it was feasible to implement this while the remaining educational portions of the project and order sets were being created, and (3) this medication initially was planned for implementation much earlier than the full protocol but was delayed due to external circumstances. Prior to March 2, 2021, intrathecal morphine was not available for use, was not stocked in the pharmacy, and was not part of the intrapartum or postpartum regimen. We previously had a standardized post-cesarean analgesia protocol comprised of scheduled acetaminophen and NSAIDs.[8] Prior to 2021, intrathecal morphine was not used due to early concerns related to respiratory compromise.[13] However, we found that our approach of using systemic opioids rather than intrathecal morphine resulted in a 112-fold higher rate of moderate to severe respiratory events than would be expected with intrathecal morphine.[7,14] Accordingly, we pivoted to implement intrathecal morphine.

Table 1. Characteristics of Patients Pre- and Post-implementation of an Enhanced Recovery After Cesarean Surgery Protocol (ERAS Protocol)

Characteristic	Pre-ERAS (n = 973)	Post-ERAS (n = 1025)	*P* value
Demographic Characteristics			
Maternal age, mean ± 4 SD	31.8 ± 4.9	32.0 ± 5.2	0.390
Married,[a] n (%)	744 (76.5)	774 (75.5)	0.818
Insurance, n (%)			0.9171
Private	768 (78.9)	817 (79.7)	
Medicaid or other public insurance	201 (20.7)	204 (19.9)	
Self-pay, no insurance, other	4 (0.4)	4 (0.4)	
Race, n (%)			0.3954
Asian or Indian	76 (8)	72 (7.2)	
Black	83 (8.7)	84 (8.5)	
Other or not specified[c]	7 (0.7)	15 (1.5)	
White	784 (82.5)	823 (82.8)	
Latinx ethnicity, n (%)[d]	82 (8.4)	114 (11.1)	0.051
Maternal BMI (prepregnancy), mean ± SD	28.7 ± 7.4	29.0 ± 7.9	0.369
Maternal BMI (at delivery), mean ± SD	34.1 ± 7.1	34.4 ± 7.6	0.596
Gravidity,[b] n (%)			0.904
1	362 (37.2)	368 (35.9)	
2	283 (29.1)	300 (29.3)	
3	148 (15.2)	156 (15.2)	
4+	179 (18.4)	200 (19.5)	
Maternal History			
Any diabetes, n (%)	187 (19.2)	191 (18.6)	0.782
Obstetric Characteristics			
Multiple gestation, current pregnancy, n (%)	56 (5.8)	56 (5.5)	0.852
Gestational age at delivery, mean ± SD	38.2 ± 2.4	38.1 ± 2.5	0.340
Infant birthweight (grams), mean ± SD	3241 ± 716	3198 ± 742	0.184
Surgical and Postpartum Characteristics			
Primary versus repeat cesarean birth			0.925
Primary, n (%)	583 (59.9)	611 (59.6)	
Repeat, n (%)	390 (40.1)	414 (40.4)	
Unplanned cesarean birth, n (%)	322 (33.1)	405 (39.5)	**0.003**
Anesthesia modality			
General anesthesia, n (%)	44 (4.5)	45 (4.4)	0.973
Epidural anesthesia, n (%)	367 (37.7)	402 (39.2)	0.520
Spinal anesthesia, n (%)	565 (58.1)	591 (57.7)	0.868

Abbreviation: BMI, body mass index.
Bold font indicates statistical significance.
[a]Marital status was unknown for 1 person in the pre-ERAS and 1 person in the post-ERAS group.
[b]Gravidity data unknown for 1 person in the pre-ERAS and 1 person in the post-ERAS group.
[c]Other racial categories here included American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, and those who chose to not self-identify. Due to low numbers, these designations were grouped to preserve anonymity.
[d]Unknown for 30 people in the pre-ERAS and 21 people in the post-ERAS group.

The ERAS protocol for the prehospital and preoperative period is shown in Supplemental Table 2, with new items indicated by ‡. Among other components of this protocol, at a preoperative visit, patients undergoing planned cesarean births receive multimedia education via in-person counseling, brochures, and a standardized video.[2] The video is available via the hospital website in English and Spanish, as well as YouTube and loaded on tablet devices in clinics and at the hospital (Links: https://

www.unitypoint.org/madison/cesareanbirth.aspx or https://www.youtube.com/watch?v=x1UJysNQKkA). Patients undergoing unplanned cesarean birth are counseled about what to expect by the clinicians and, when time permits, a visual flip-chart aid with diagrams is used to standardize this conversation. Patients undergoing unplanned cesarean delivery also may watch the pre-cesarean educational video if time permits. The contents of the video include how to prepare for a cesarean birth, what to expect, and how postoperative pain will be managed.

The perioperative and intraoperative protocol is shown in Supplemental Table 3.[4,6,11,15] Starting March 2, 2021, intrathecal morphine was added to the spinal and epidural anesthesia regimen. Dosing is indicated in Supplemental Table 3. Patients who underwent general anesthesia without neuraxial analgesia did not receive neuraxial morphine.

Intraoperative considerations included recommendations to avoid a bladder flap, with instructions that foregoing a bladder flap reduces time to delivery, surgical site infection, time to void, urinary retention, and adherence of the bladder to the uterus in subsequent pregnancies, but also that provider discretion is reasonable.[6] Promoting early skin-to-skin contact was implemented in a systematic manner as part of the ERAS protocol, with the pediatric team assessing the baby on the operative field during delayed cord clamping and allowing immediate skin-to-skin contact if further assessment on the warmer was not required.[4,6,12]

Table 2. Percentage of Postpartum People Utilizing ≤15 MMEs Within a Given Time Period and With Severe Pain Scores (≥7) Pre- and Post-ERAS Protocol Implementation

Time Period	Pre-ERAS (n = 973)	Post-ERAS (n = 1025)	*P* value
Percentage who utilized zero MMEs	n (%)	n (%)	
0 – < 6 hours	111 (11.4)	687 (67.0)	**< 0.001**
6 – <12 hours	84 (8.6)	777 (75.8)	**< 0.001**
12 – < 24 hours	86 (8.8)	683 (66.6)	**< 0.001**
24 – < 48 hours	133 (13.7)	533 (52.0)	**< 0.001**
48 – < 72 hours	285 (29.3)	644 (62.8)	**< 0.001**
72 hours – hospital discharge	624 (64.1)	851 (83.0)	**< 0.001**
Percentage who utilized ≤15 total MMEs	n (%)	n (%)	
0 – < 6 hours	260 (26.7)	950 (92.7)	**< 0.001**
6 – < 12 hours	175 (18.0)	924 (90.1)	**< 0.001**
12 – < 24 hours	130 (13.4)	787 (76.8)	**< 0.001**
24 – < 48 hours	167 (17.2)	617 (60.2)	**< 0.001**
48 – < 72 hours	357 (36.7)	736 (71.8)	**< 0.001**
72 hours – hospital discharge	690 (70.9)	915 (89.3)	**< 0.001**
Percentage of patients with any pain score ≥ 7[a]	n (%)	n (%)	
0 – < 6 hours	278 (32.0)	141 (21.2)	**< 0.001**
6 – <12 hours	164 (19.2)	48 (8.6)	**< 0.001**
12 – < 24 hours	179 (19.7)	101 (13.8)	**0.002**
24 – < 48 hours	164 (17.6)	182 (21.1)	0.070
48 – < 72 hours	102 (12.7)	96 (14.1)	0.496
72 hours – hospital discharge	53 (12.2)	33 (10.4)	0.516

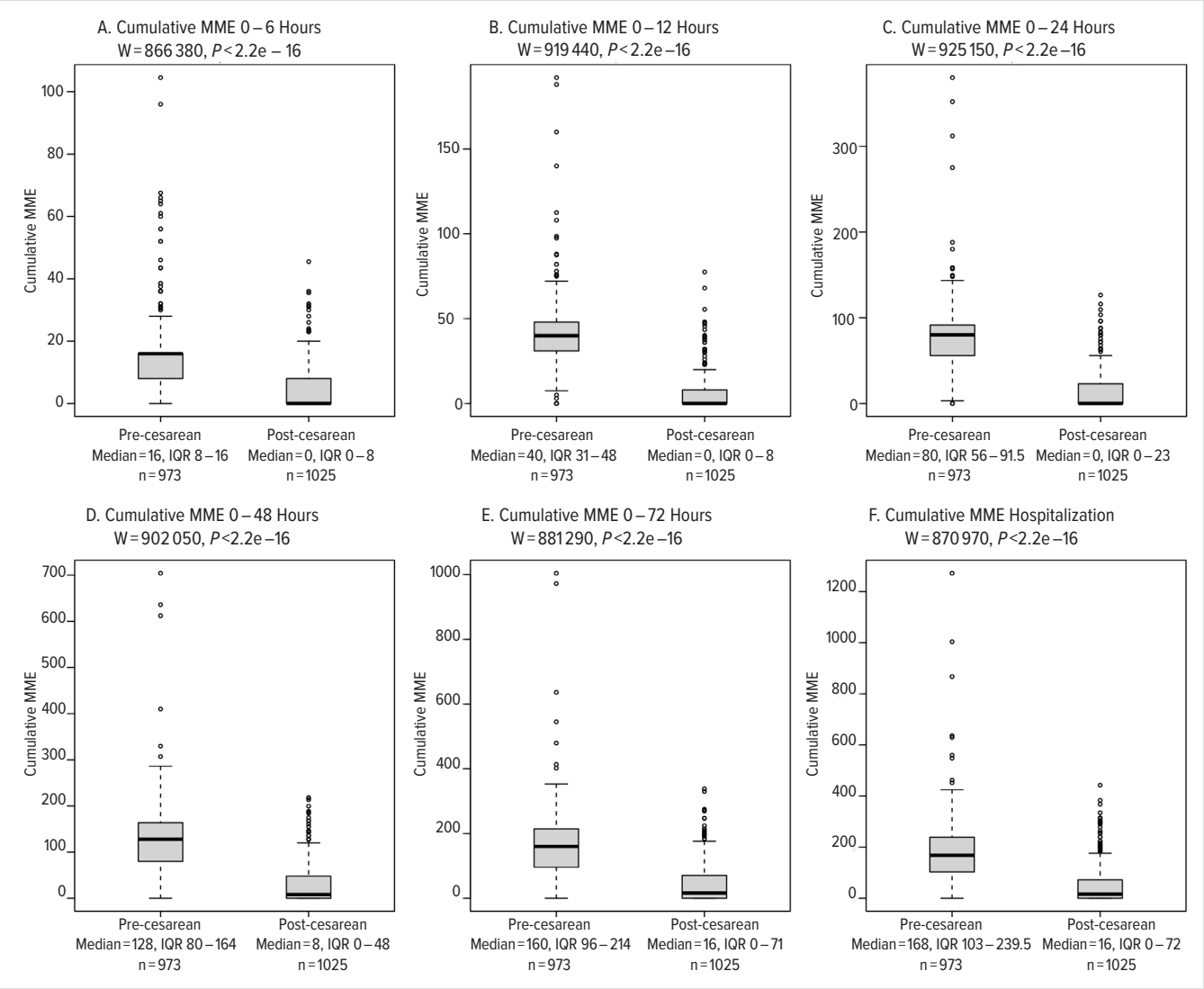
Abbreviations: MME, morphine milligram equivalents; ERAS, enhanced recovery after cesarean surgery.
Bold font indicates statistical significance; *P* values are based upon chi-square or Fisher exact tests.
[a]Denominators only include those with pain scores recorded. For 0 – <6 hours, 869 and 664 people had pain scored recorded for the pre and post-ERAS, respectively; for 6 – <12, 832 and 561; for 12 – <24 hours, 907 and 730; for 24 – <24 hours, 933 and 864; for 48 – <72 hours, 801 and 682; for 72 hours hospital discharge, 434 and 317.

The postpartum ERAS protocol is shown in Supplemental Table 4. Acetaminophen (975 mg orally) and NSAIDs (ketorolac 15 mg intravenously [IV] for the first 24 hours followed by ibuprofen 600 mg orally) are administered every 6 hours simultaneously, which was the case in both the pre-ERAS and post-ERAS period.[8] Opioids – oral or IV – could be administered as needed for breakthrough pain. These typically comprised oral morphine or hydromorphone, but different agents were available or used due to medication shortages or patient factors. New items include earlier removal of the indwelling urinary catheter within 6 rather than 12 hours.[4,16] Early oral nutrition and gum chewing was encouraged.[3,4,11] A postoperative educational video was created with instructions to view the video as early as feasible during the postpartum period. The contents of this video were similar to the preoperative video but with the preparation steps omitted and a few notes about unexpected cesarean births. Finally, routine discharge at post-cesarean day 2 was encouraged.

Education for nurses and all obstetric providers (including resident physicians, certified nurse midwives, family medicine physicians, and obstetricians) was required and made available starting 1 month prior to implementation, allowing time to complete the educational modules. The modules included information on each new portion of the protocol and the rationale for inclusion. The module was followed by a short quiz. Reminder emails were sent to those who did not complete the training modules and the quiz. Reminder fliers were posted on the maternity unit. All modules were to be completed by the implementation date of June 29, 2021, which was the date that use of the order sets was required.

Data were collected for the following date ranges: "pre-ERAS" June 1, 2020-March 1, 2021; "partial" March 3, 2021-June 28, 2021, at which time only the intrathecal morphine portion of the protocol was started; and "post-ERAS" June 29, 2021-March 31, 2022. The primary analysis compared the pre-ERAS to the post-ERAS period. To collect demographic data, we queried the hospital's administrative birth database (PeriData.Net, Ancilla Partners, Inc, Milwaukee, Wisconsin) to generate a list of all cesarean births that occurred during the dates analyzed. Briefly,

Figure 1. Median Cumulative MME Utilization Among the Pre-ERAS and Post-ERAS Groups in (A) the First 6 Hours Post-cesarean, (B) the First 12 Hours Post-cesarean, (C) the First 24 Hours Post-cesarean, (D) the First 48 Hours Post-cesarean, (E) the First 72 Hours Post-cesarean, and (F) From Cesarean Until Discharge From the Hospital



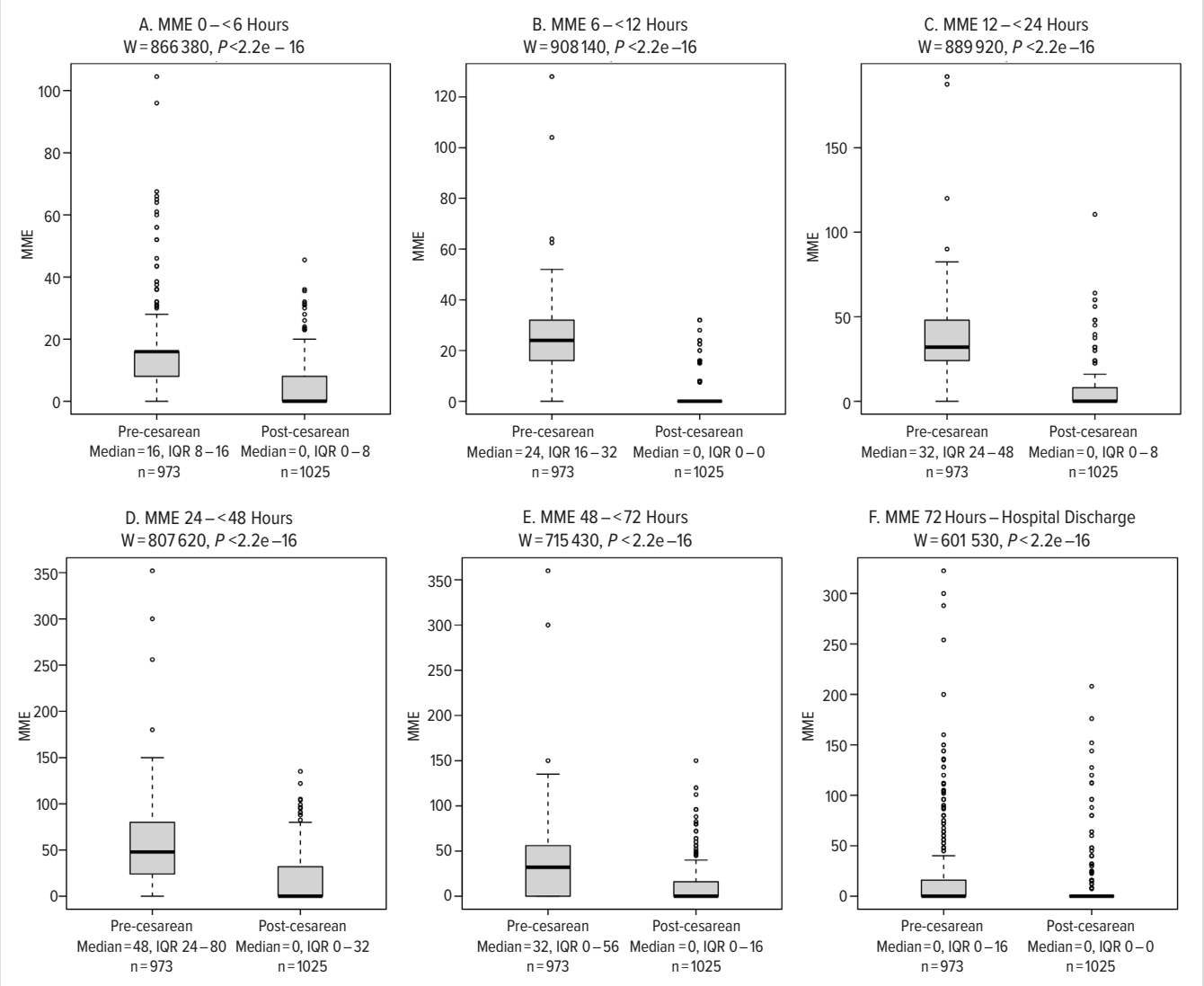
Abbreviations: MME, morphine milligram equivalents; ERAS, enhanced recovery after cesarean surgery.
P values are based on Wilcoxon rank sum tests.

data entry is performed manually via review of information from parents supplemented by review of the hospital's electronic health record.[7,8] All data are audited by perinatal data coordination nursing staff.[7,8] We simultaneously queried the electronic health record system (Epic, Hyperspace 2021, Epic Systems Corporation, Verona, Wisconsin) for recorded pain scores and medication use.

Inclusion criteria for this analysis were cesarean delivery during the indicated time periods. Exclusion criteria included the following: chronic opioid use due to either chronic pain or opioid use disorder due to likely outlier status for post-cesarean opioid utilization and ongoing intubation after completion of cesarean surgery because such patients often receive opioids for purposes unrelated to pain.

The primary outcome was cumulative opioid dose in the first 48 hours postoperatively among the pre-ERAS group versus the post-ERAS group. Doses were converted to MMEs and summed.[17] Secondary outcomes included MME utilization and pain scores at other time intervals. Pain scores from 0 to 10 using the numeric rating scale were collected by nurses at least every 6 hours.[18] Using this pain scale, scores of 0 correspond to no pain, 1 to 3 corresponds to mild pain, 4 to 6 corresponds to moderate pain, and 7 to 10 corresponds to severe pain.[18] Nurses also qualitatively assess the nature of pain and subjectively assess how much pain the patient appears to be experiencing. We assessed the percentage of postpartum people with at least 1 pain score ≥7; the percentage who utilized < 15 MMEs for the whole hospitalization; and the percentage who utilized zero MMEs. A pain score ≥7 was

Figure 2. Median MME Among the Pre-ERAS and Post-ERAS Groups in (A) the First 0 – < 6 Hours Post-cesarean, (B) 6 – < 12 Hours Post-cesarean, (C) 12 – < 24 Hours Post-cesarean, (D) 24 – < 48 Hours Post-cesarean, (E) 48 – < 72 Hours Post-cesarean, and (F) 72 Hours Post-cesarean Until Discharge From the Hospital



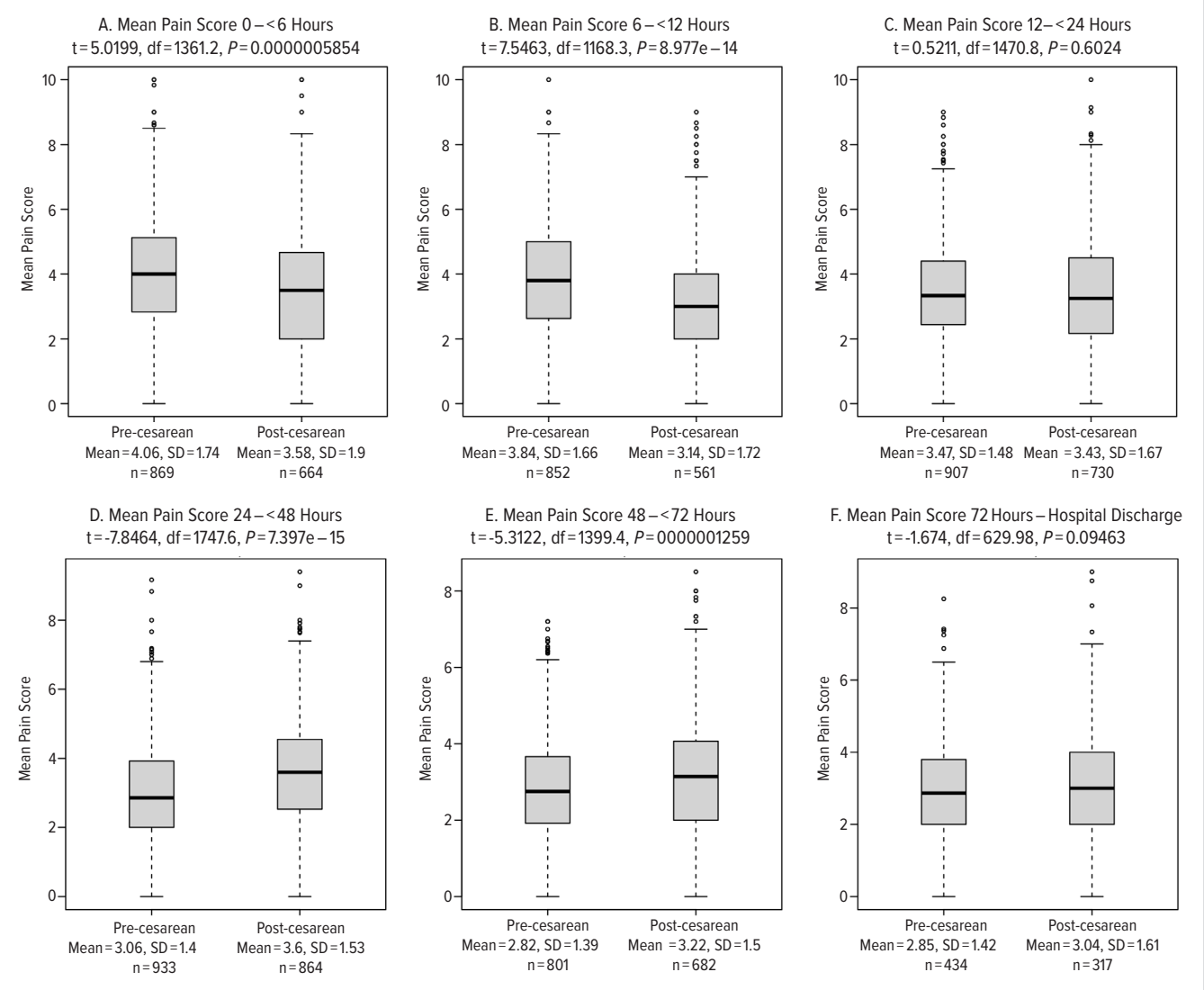
Abbreviations: MME, morphine milligram equivalents; ERAS, enhanced recovery after cesarean surgery.
P values are based on Wilcoxon rank sum tests.

chosen as a cutoff because this signifies severe pain. The threshold of 15 MMEs for the whole hospitalization was evaluated because prior investigators used this as a cut-off at which patients were considered to be "opioid spared." Additional variables collected included body mass index (BMI), age, race/ethnicity, gravidity, parity, and gestational age at delivery. Medical comorbidities and obstetric outcomes were defined as per the American College of Obstetricians and Gynecologists.

To assess compliance with the ERAS protocol, the following items were audited: pre-cesarean glucose beverage consumed (for planned cesarean births only), intrathecal morphine administered, intraoperative temperature obtained, pre-cesarean video viewed, and post-cesarean video viewed.

Based upon our hospital data, in 2019, average cumulative opioid utilization in the first 48 hours post-cesarean birth was 134.9 MME with a standard deviation of 66.2 MME.[8] Given this average baseline data, we anticipated that we would require a sample size of at least 114 to detect a 30% reduction in cumulative opioid dose, accommodating a wide standard deviation, with 80% power and alpha of 0.05. In order to assess our secondary outcomes, we included patient charts for the time period for all who met criteria. Demographic and outcome measures were compared pre-ERAS and post-ERAS using *t* test or Wilcoxon rank sum for normally and non-normally distributed continuous measures, respectively, and chi-square or Fisher exact test for categorical measures. Post hoc analyses of the pre-ERAS, partial-ERAS (intrathecal morphine only), and post-ERAS (full ERAS) groups were performed. A *P* value of < 0.05 was considered statistically significant. R program-

Figure 3. Mean Pain Scores Among the Pre-ERAS and Post-ERAS Groups in the First (A) the First 0 – <6 Hours Post-cesarean, (B) 6 – <12 Hours Post-cesarean, (C) 12 – <24 Hours Post-cesarean, (D) 24 – <48 Hours Post-cesarean, (E) 48 – <72 Hours Post-cesarean, and (F) 72 Hours Post-cesarean Until Discharge From the Hospital



Abbreviations: MME, morphine milligram equivalents; ERAS, enhanced recovery after cesarean surgery.
P values are based on *t* tests.

ming language was used for all statistical analyses (R Core Team, 2020).

RESULTS

From June 1, 2020, through March 31, 2022, 2522 patients were delivered via cesarean. One hundred seven were excluded due to chronic opioid use (n = 98) or post-cesarean intubation (n = 9). From June 1, 2020, to March 1, 2021, 973 were delivered and were included in the "pre-ERAS" group; 1025 were delivered from June 29, 2021, through March 31, 2022, and were included in the "post-ERAS" group; and 417 were delivered during the time from March 2, 2021 through June 28, 2021 and were included in the "partial" group but were excluded from the primary analysis. During the "partial-ERAS" time period, only intrathecal morphine had been implemented. During the "post-ERAS" period the full ERAS protocol had been implemented. Baseline characteristics of the 2 groups were similar except that in the post-ERAS group, more patients experienced unplanned cesarean birth.

The primary outcome of cumulative MME in the first 48 hours after cesarean birth was significantly different between groups with higher MME utilized in the pre-ERAS group compared to the post-ERAS group (median 128 [IQR 80-164] MME vs 8 [IQR 0-48] MME, respectively; Wilcoxon rank test $P < 0.001$) (Figure 1D). Cumulative MME utilization and MME utilization for each time interval was similarly lower in the post-ERAS group (Figures 1 and 2). The percentage of patients who utilized 0 MME and <15 MMEs was significantly lower among the post-ERAS group (Table 2).

Regarding the secondary outcome of pain scores, mean pain scores were lower for the 0 to 6 hours and 6 to 12 hours interval among the post-ERAS group. For the 12- to 24-hour post-cesarean interval and the interval from 72 hours until discharge, there was no statistical difference in pain scores (Figure 3). For the 24- to 48-hour and 48- to 72-hour interval, pain scores were higher in the post-ERAS group. Fewer patients reported pain scores >7 in the post-ERAS group for the first 24 hours post-cesarean (Table 2) but not beyond 24 hours.

Postpartum length of stay was decreased in the post-ERAS group from 3.1 days (SD 0.9) pre-ERAS to 2.9 days (SD 0.9) post-ERAS, (*t* test $P<0.001$).

To determine whether the full ERAS protocol was associated with further MME reduction versus intrathecal morphine alone, the partial-ERAS group was compared to the post-ERAS group. Baseline characteristics between the partial-ERAS and post-ERAS groups were similar with no statistically significant differences in evaluated characteristics (data available upon request). The median opioid utilization at all time periods was similar between groups (Supplemental Figures 1 and 2). Pain score results were similar except that pain scores in the post-ERAS group were slightly higher in the first 0 to 6 hours post-cesarean than in the intrathecal morphine only group, median 3.3 (SD 1.9) versus 3.6 (SD 1.9) for the partial versus post-ERAS groups, respectively (Supplemental Figure 3). The percentage who reported pain scores >7, the percentage who utilized zero MMEs, and the percentage who utilized <15 MMEs were not statistically different between the partial versus post-ERAS groups (Supplemental Table 5). When comparing the pre-ERAS group to the partial-ERAS group, statistically significant differences in both cumulative MME utilization and in the percentage of patients who utilized zero MMEs and <15 MMEs were noted (supplemental Figure 4 and Supplemental Table 6).

Regarding compliance, during the post-ERAS period, the preoperative glucose beverage was administered 608 times for 620 (98.1%) planned cesarean cases. During the partial-ERAS period, 398 of 417 (95.4%) patients undergoing cesarean birth received intrathecal morphine; during the post-ERAS period, 1000 of 1025 (97.5%) patients undergoing cesarean birth received intrathecal morphine. Intraoperative temperature was documented for 1023 (99.8%) cases post-ERAS. The preoperative video was watched an average of 3.9 times daily and the post-cesarean video was watched an average of 4.5 times daily, which exceeds the average number of cesareans births performed daily (3.4). Of video viewings, 11.5% were for the Spanish language version.

DISCUSSION

Following implementation of this post-cesarean ERAS protocol, total opioids utilized in the first 48 hours following cesarean birth decreased by 93.8%. A decrease in opioid utilization was observed at all other time periods. The percentage of patients who utilized zero and <15 MMEs was higher following implementation of this ERAS protocol. MME utilization was statistically significantly lower after implementation of intrathecal morphine alone (partial-ERAS) than during the pre-ERAS period, suggesting that this was the main driver of decreasing opioid dose. Further reductions in opioid utilization after the implementation of the full protocol were limited by low opioid utilization in both the "partial" and post-ERAS time periods.

Our secondary outcome measure of mean pain scores was lower at time periods prior to 12 hours postpartum. The 12- to 24-hour time period is the timeframe where the effects of intrathecal morphine would be expected to wane; thus, this might explain the lack of a difference in pain control in this time period.[19] After 24 hours, pain scores were statistically higher in the post-ERAS group compared to the pre-ERAS group, while MME utilization remained statistically lower. The clinical significance of the difference in pain scores is small, but this suggests that after implementation of the ERAS protocol, pain in the 24- to 48-hour period was less aggressively treated with opioids. Another possible explanation is that patients were more tolerant of mild pain without requesting opioids due to the educational interventions of the ERAS protocol. The absolute differences in pain, while statistically significant, are of unclear clinical significance. We did not capture patient satisfaction scores, but it will be important to consider whether additional efforts are warranted to reduce pain beyond 24 hours post-cesarean. The percentage of subjects with severe pain—scores ≥7—was lower in the first 24 hours post-cesarean in the post-ERAS group, but this was no longer observed after 24 hours.

Prior investigations, quality improvement projects, trials, and meta-analyses have similarly found that implementation of enhanced recovery after cesarean surgery protocols is associated with decreased opioid consumption in the post-cesarean time period,[11,12] decreased pain,[11,12] shorter length of stay,[12] decreased hospital costs,[20] and increased patient satisfaction.[20] Some also notably found no change in opioid utilization,[21] pain scores,[22] or length of stay.[11] Each ERAS protocol differs, which may affect the impact on each of these outcomes. Here, we uniquely evaluated the impact of intrathecal morphine separately from the full ERAS protocol and found that intrathecal morphine is the most impactful component in terms of reducing cumulative MME utilization. These results support wider implementation of ERAS protocols that include intrathecal morphine—especially at institutions with above-average post-cesarean opioid utilization.

We and other institutions have identified racial disparities in treatment of post-cesarean pain.[23,24] One institution has demonstrated that their ERAS protocol reduced racial disparities in postoperative pain scores.[25] Further analysis regarding whether our ERAS protocol reduced disparities is planned.

Our strengths included the following: this project was implemented in the largest delivering hospital in Wisconsin, which allowed for a large sample size. Our multidisciplinary team encompassed all phases of clinical and hospital care that patients

undergoing cesarean births encounter. The staggered implementation of intrathecal morphine and the full protocol allowed us to evaluate whether ERAS was associated with further reduction in MME utilization and pain compared to intrathecal morphine alone. While this was a before-and-after analysis, the obstetrical care teams, anesthesia teams, and patient population before and after the intervention were similar. While not yet published when this protocol and analysis were being planned, we have included many of the standardized outcome measures proposed by the CRADLE (Curating Research Assets and Data Using Lifecycle Education) investigators, including the length of hospital stay, postpartum opioid consumption, and compliance.[26]

Our analysis has limitations. In our analysis comparing the partial protocol to the post-ERAS time period, the median MME utilization for both time periods was low at 8 MME. This low MME and the lower sample size limited our ability to assess further reductions in MME utilization after implementation of the full protocol. This single institution has limited racial/ethnic diversity, which limits generalizability. Mental health diagnoses can impact postoperative pain, but these are not captured in our hospital's administrative database and could not be accounted for.[27] However, such diagnoses are unlikely to differ in this before-and-after population over a short time span. We previously demonstrated that unplanned cesarean birth is associated with higher pain and MME utilization after delivery among people with anxiety.[27] The higher prevalence of unplanned cesarean births in the post-ERAS time period would be expected to potentially limit our findings of less MME utilization in the post-ERAS period. We were not able to assess measures that are less well documented in the medical record, such as time to oral intake or ambulation. We lack patient experience data, which limits our ability to assign clinical significance to the small numeric increase in pain scores.

CONCLUSIONS

ERAS protocols are recommended by many anesthesia and obstetrical societies and a variety of guidelines and reviews are available.[2-6] We provide further evidence that ERAS protocols—particularly one including intrathecal morphine—can reduce MME utilization by 93.8% at a high volume teaching-community hospital with historically high MME utilization after cesarean birth.[7,8] While there was no further reduction in MME utilization with the full ERAS protocol than with intrathecal morphine alone, the median MME during both time periods was low, which limits the ability to measure further reductions. Notably, pain scores increased after 24 hours post-cesarean. Accordingly, ongoing research efforts should focus on pain control after the first 24-hour time period.

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Appendices: Supplemental Materials available at www.wmjonline.org.

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Supplemental Table 1. Members of the ERAS Protocol Committee

Members of the ERAS protocol committee
Obstetrics and gynecology providers
-Academic practice providers
-Representatives from each private practice group
-Resident physician
-Maternal-fetal medicine physician
-Midwife
Anesthesiology
Hospital and clinical nursing for each phase of care
-Clinic
-Triage
-Birthing center
-Operating room
-Postpartum floor nurses
Nursing administration
Pharmacy
Patient education specialist
Provider education specialist
Electronic health record (Epic) personnel
Nutrition
Hospital administration.

The committee was comprised of representatives from every phase of prenatal, intrapartum, and postpartum care

Supplemental Table 2. Preoperative Portion of ERAS Protocol

Pre-operative: Prior to hospital	**Description**
Address anemia[1–4]*†	
At 24-28 weeks, CBC	If Hgb≤10 g/dL **AND** iron deficient, treat with oral iron.
Repeat labs 4 weeks later‡	If not resolved, administer IV iron infusion.[5,6]‡
Patient education at pre-operative visit (typically 36-38 weeks) [1,2,7,8]	Verbal counseling during preoperative visit about pain expectations and other instructions given by their provider
Handouts	Written brochures and booklets
Pre-operative video‡	Available via hospital website in English and Spanish, also on YouTube and loaded on tablet devices in clinic.‡ Link: https://www.unitypoint.org/madison/cesareanbirth.aspx -Link to the video is available as a QR code on a poster in clinic rooms -Clinic-owned tablet devices are available to watch the video while waiting for appointments or during non-stress tests, -Direct links to the videos are available on computers in the clinical examination rooms.
Reminder call 24 hours prior to procedure[7,8]	Remind patient to watch video, about oral intake instructions, to use chlorhexidine wipes, and to present 2.5 hours prior to scheduled case
Special cases such as anticoagulation medication timing	Individualized. There is a prompt to discuss this on the pre-operative note template and videos and handouts recommend patients ask their providers about relevant instructions
Skin Prep	
Chlorhexidine wipes used at home[7]	Instructed to use over the whole body except the breasts
Fasting and nutrition[1,2,7,8]	
No prolonged fasting-solids[1,7,8]	Solids allowed up to 8 hours before scheduled hospital arrival‡
No prolonged fasting-liquids[2,8]	Clear liquids allowed up to 2 hours before scheduled surgery‡
Known diabetes	Ideally (if feasible) schedule as 1st or 2nd case of day[1,9]‡
Pre-operative: At hospital	**Description**
Patient education[1,2,7,8]	
Handouts	Written brochures, booklets, and a flip chart about what to expect during an unplanned cesarean
Pre-operative video‡	On hospital website in English and Spanish, also on YouTube and loaded on tablet devices on the labor floor‡
Skin Prep & Infection Prevention	
Hair at surgical site clipped	Clipped not shaved
Chlorhexidine wipes to use at hospital	Applied over abdomen, pelvic area, and legs
Temperature taken	
Glucose	
Known diabetes	Glucose check on arrival and manage as per intrapartum glucose protocol, treating glucose values >110 mg/dL.‖
No known diabetes‡	Glucose check on arrival. If >110 mg/dL, manage as per intrapartum glucose protocol, still do carbohydrate loading
Fasting and nutrition[1,2,7,8]	
Carbohydrate loading (unless T1DM) ‡§	Ensure Clear Therapeutic Nutrition, 6.8 oz, 43 g carbs, 200 calories at 2-2 ½ hours prior to procedure.
Medications	
Antacids and H2 blockers	

-Planned CD	Oral Bicitra, famotidine, and metoclopramide
-Unplanned CD	Oral Bicitra and IV famotidine and metoclopramide (time permitting)

* CBC=Complete blood count.
†Anemia is associated with low birthweight, preterm birth, and postpartum transfusion, thus is treated.[2–4] For anemia that persists four weeks after starting oral iron, intravenous iron is recommended.[5,6]
‡Denotes items that were not performed prior to the implementation of this protocol
§T1DM=type 1 diabetes mellitus
‖ Values that exceed 110 mg/dL are managed with insulin to both reduce the risk of surgical site infection (target <150 mg/dL) and to reduce the risk of neonatal hypoglycemia (target <110 mg/dL). Following this check, a carbohydrate beverage is given to aid in insulin sensitivity and to promote post-cesarean bowel function unless a patient has type 1 diabetes.[1,2,7,8] If treatment is initiated, glucose values are rechecked hourly. For patients with diabetes with normal initial glucose values, glucose values are repeated hourly prior to surgery so that insulin can be administered if required. For patients undergoing an unplanned cesarean birth, the glucose is checked and treated unless the urgency of the case precludes it.

Supplemental Table 3. Peri- and Intraoperative Portion of ERAS Protocol

Peri- and intraoperative time period	Description
Antibiotics	
Timing	Intravenous antibiotics should be administered within 60 minutes before the cesarean delivery skin incision and at least 15 minutes before incision[7,10] and repeated as needed for cases longer than 4 hours for cefazolin (2 hours for cefoxitin) or blood loss over 1500 mL.[11,12]
Specific antibiotics*	
Scheduled and unlabored	Cefazolin, weight-based dosing[11]
Labor or with ruptured membranes	Cefoxitin and azithromycin[13]
Skin / Site Prep & Infection Prevention	
All cesarean deliveries	Chlorhexidine scrub for scheduled and urgent cases[7,10] Povidone iodine if unable to wait 3 minutes
Labor or with ruptured membranes	Vaginal preparation with 4.0% chlorhexidine gluconate[14]
Intraoperative glove change	Change gloves prior to fascial closure and close with separate instrument tray.[15]
Maintenance of normothermia[1,7]	
Warm IV fluids†→	Unless fever >38°C present If temp <36°C, forced-air patient warming device is added
Temperature taken after delivery	
Glucose	Continue glucose checks and insulin if indicated based upon pre-operative glucose
Anesthesia	Intrathecal or epidural morphine‡§¶
Nausea and vomiting[1,7]	
Avoid uterine exteriorization	
Fluid preloading	Reduce hypotension
Consider medications†	Phenylephrine bolus or infusion and ondansetron 4 mg If vasopressors contraindicated, use two antiemetics
Breastfeeding and infant[1]	
Delayed cord clamping[1,10]	-Delayed cord clamping for at least 1 minute at term delivery recommended[10] -Delayed cord clamping for at least 30 seconds at a preterm delivery recommended.[10] No cord milking for preterm deliveries.
Skin to skin contact as soon as possible[8,10,16]†	-Newborn provider attending delivery will assess baby on OR field during delayed cord clamping. - Newborn provider will determine if baby meets NRP criteria for skin to skin (appears term, has good tone, has good respiratory effort) or requires further assessment on warmer. --Newborn provider attending delivery has final determination on whether skin-to-skin is appropriate for any given baby --Anesthesia team, parents, or other providers may cancel skin-to-skin if there are anesthesia/ patient concerns --Newborn provider attending delivery should stay in the room for at least 5 minutes to ensure transition is uneventful --Ongoing frequent monitoring of vital signs

	-For preterm deliveries, individualize. Skin-to-skin may be possible for some select late preterm cases, but this will be to the pediatric provider's discretion
Operative considerations	
Avoid bladder flap[10,17–21]†	Avoiding bladder flap reduces SSI and time to void but provider discretion is reasonable.

* For patients with allergies, chorioamnionitis, or group B streptococcus who were already undergoing prophylaxis, order sets created by a multi-specialty team with guidance from the American College of Obstetricians and Gynecologists specify the antibiotic(s) to use for cesarean surgical site infection prophylaxis.[11,22]

†Denotes items that were not performed prior to the implementation of this protocol

‡Intrathecal morphine was initiated in 03/02/2021, three months prior to the remainder of the protocol

§ Morphine administered intrathecally if a spinal anesthetic planned at the initiation of regional analgesia in either a spinal or a combined spinal-epidural at a dose of 100 mcg in addition to 15 mcg of fentanyl, 12 mg of bupivacaine (occasionally a lower dose for short stature or if patient had an epidural and recently received boluses) and intrathecal epinephrine 0-200 mcg at the discretion of the anesthesiologist. If morphine was administered via epidural, it was administered after clamping of the umbilical cord at a dose of 2 mg epidural morphine once along with and 100 mcg of epidural fentanyl along with 0.5% bupivacaine, 2% lidocaine, or 3% chloroprocaine at the discretion of the anesthesiologist.

¶Contraindications to intrathecal morphine were rare but included serious allergic reaction to morphine or occasional very high-risk medical conditions at the discretion of the anesthesiologist.

Supplemental Table 4. Postoperative Portion of ERAS Protocol

Postoperative time period	Description
Antibiotics	Unless ongoing infections, discontinue within 24 hours
Skin	
Remove dressing at 48 hours CHG wash for showering	Use CHG scrub in lieu of regular soap to wash abdominal area-allow soap/ soap suds to drip over incision with first shower and continue until bottle is empty after discharge to home.‡
Venous thromboembolism prophylaxis	
For all For high risk	Pneumatic compression stockings[9] Enoxaparin per hospital protocol
Glucose[9]	
Maintain glucose <150 for 24 hours	As per SSI protocol‡
Multimodal analgesia[1,7,8,23,24]	
Scheduled NSAID	Ketorolac 15 mg IV Q 6 hours x 24 hours followed by Ibuprofen 600 mg PO Q 6 hours
Scheduled acetaminophen	975 mg PO Q 6 hours
Opioids for breakthrough pain only	For moderate to severe pain
Early return to function[7]	
Early ambulation[9]	Ambulation accomplished within 12 hours after surgery
0-8 hours postop*/ 0-6 hours after arrival to postpartum unit	• Sit on edge of bed • Out of bed to chair at 4-6 hours post-cesarean • Ambulation if tolerated and no contraindications
8-24 hours postop*/ 10-22 hours after arrival to postpartum unit	• Ambulation as tolerated by 12 hours post-cesarean • Minimum of 2 ambulations in the hallway *Unless on magnesium or other contraindication to ambulation
25-28 hours postop	• Walk 3-4+ times in hallway • Out of bed for 8+ hours
Early urinary catheter removal[1,16,25,26]*	Removal of urinary catheter within 4-6 hours of surgery/ *Unless on magnesium or other contraindication to ambulation
Restoration of gut function [7]	
Early oral nutrition[7]	• Ice chips and/or water within 60 minutes of admission to PACU[1] • Regular diet within 2 hours of surgery[8,9] OR • Regular diet allowed upon arrival to postpartum floor
Chewing gum[1,7]*	Consider, especially if delayed oral intake is planned May start immediately after operation. Chew gum 3-6 times daily for 15-60 minutes Patients may bring own gum from home or purchase in the cafeteria or gift shop
IV	
Lock IV early	Lock once oxytocin infusion complete, tolerating oral intake, and urine output adequate[1] within 2-3 hours of arrival to postpartum unit
Remove IV at 24 hours postop	
Optimize rest	
Limit unnecessary interruptions*	Cluster vitals, analgesia administration[1]
Anemia remediation[1]†	
For hemoglobin <10 mg/dL*	Iron sulfate 325 mg PO BID*

	Ascorbic acid PO BID *Avoid in people with prior roux-en-y bypass and inflammatory bowel disease. IV iron may be considered
For hemoglobin ≤9 mg/dL*	Iron sucrose 200-300 mg IV daily while inpatient (total dose not to exceed 1000 mg)[27,28] Iron sulfate 325 mg PO BID upon discharge
Education	
Video education for postoperative care instructions*	Viewed as possible post-op. Can show in PACU or postpartum unit. This video specifically discusses pain expectations and management of mild, moderate, and severe pain. This video is available on the hospital website and YouTube.com and is accessible to view on a private device by scanning a QR code or viewing a video loaded directly onto a hospital-owned tablet device. Link to video: https://www.unitypoint.org/madison/cesareanbirth-postop.aspx)
Written discharge instructions[9]	
Counsel regarding pain expectations	
Wound care	
Interdry	Providers/ nurses may consider and continue to use at their discretion consistent with current use
CHG wash post-cesarean	For postoperative showering as above‡
Surface wound vac	Providers may consider and continue to use at their discretion consistent with current use
Discharge planning	Start discharge planning on POD 1
Plan for routine DC on POD 2*	Review range of POD 2-4

*Denotes items that are new with this protocol
†Postpartum anemia management: oral iron for Hgb<10 mg/dL, IV iron for Hgb<9 mg/dL and consideration for blood transfusion <8 mg/dL if symptoms were present or <7 mg/dL in the absence of symptoms.[16,28–31]
‡ Chlorhexidine for postpartum showers was introduced in 2020 as part of a surgical site infection bundle, as was monitoring to maintain blood glucose less than 150 for patients with diabetes or who were identified to have elevated blood glucose levels prior to delivery

Supplemental Table 5. Percentage of Patients with Zero MME Utilized, ≤15 MME Utilized, and Pain Scores ≥7 in the Partial-Protocol Versus the Post-ERAS Period

	Partial N=417	**Post-ERAS N=1025**	**P**
Percentage who utilized zero MMEs			
0-6 hours	280 (67.1%)	687 (67%)	1.000
6-12 hours	325 (77.9%)	777 (75.8%)	0.426
12-24 hours	293 (70.3%)	683 (66.6%)	0.203
24-48 hours	217 (52%)	533 (52%)	1.000
48-72 hours	259 (62.1%)	644 (62.8%)	0.845
72+ hours	349 (83.7%)	851 (83%)	0.818
Percentage who utilized ≤15 MMEs[32]			
0-6 hours	376 (90.2%)	950 (92.7%)	0.138
6-12 hours	381 (91.4%)	924 (90.1%)	0.537
12-24 hours	329 (78.9%)	787 (76.8%)	0.423
24-48 hours	244 (58.5%)	617 (60.2%)	0.595
48-72 hours	292 (70%)	736 (71.8%)	0.540
72+ hours	364 (87.3%)	915 (89.3%)	0.325
Percentage with pain scores ≥7[33]			
0-6 hours	52 (17.6%)	141 (21.2%)	0.222
6-12 hours	17 (6.8%)	48 (8.6%)	0.468
12-24 hours	42 (12.7%)	101 (13.8%)	0.695
24-48 hours	91 (23.9%)	182 (21.1%)	0.290
48-72 hours	46 (14.9%)	96 (14.1%)	0.811
72+ hours	13 (8.8%)	33 (10.4%)	0.720s

Supplemental Table 6. Percentage of Patients with Zero MME Utilized and ≤15 MME Utilized in the Pre-ERAS and Partial Period

	Pre-ERAS N=973	**Partial N=417**	**P**
Percentage who used zero MMEs			
0-6 hours	111 (11.4)	280 (67.1%)	<0.001
6-12 hours	84 (8.6)	325 (77.9%)	<0.001
12-24 hours	86 (8.6)	293 (70.3%)	<0.001
24-48 hours	133 (13.7)	217 (52%)	<0.001
48-72 hours	285 (29.3)	259 (62.1%)	<0.001
72+ hours	624 (64.1)	349 (83.7%)	<0.001
Percentage who used ≤15 MMEs[32]			
0-6 hours	260 (26.7)	376 (90.2%)	<0.001
6-12 hours	175 (18.0)	381 (91.4%)	<0.001
12-24 hours	130 (13.4)	329 (78.9%)	<0.001
24-48 hours	167 (17.2)	244 (58.5%)	<0.001
48-72 hours	357 (36.7)	292 (70%)	<0.001
72+ hours	690 (70.9)	364 (87.3%)	<0.001

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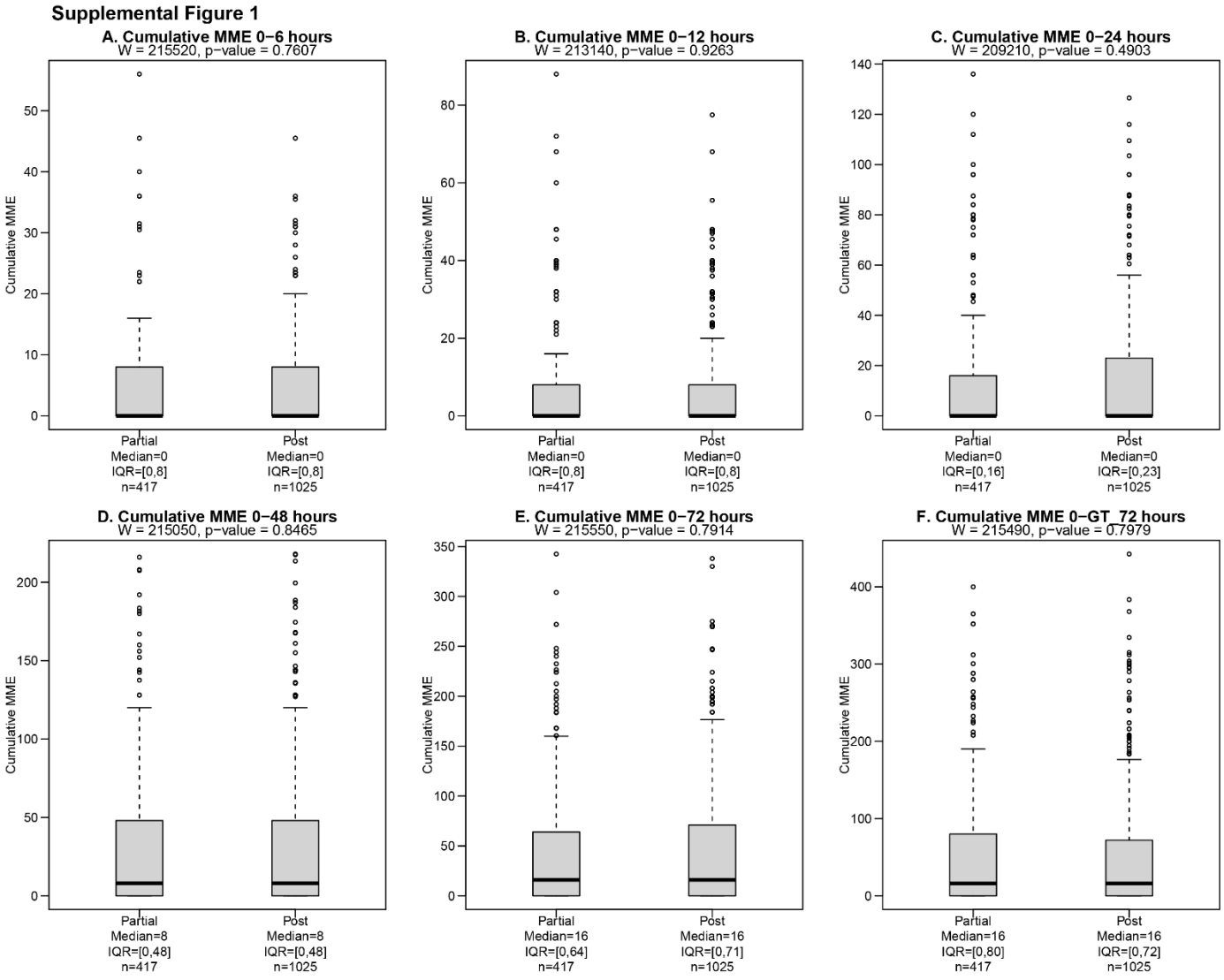
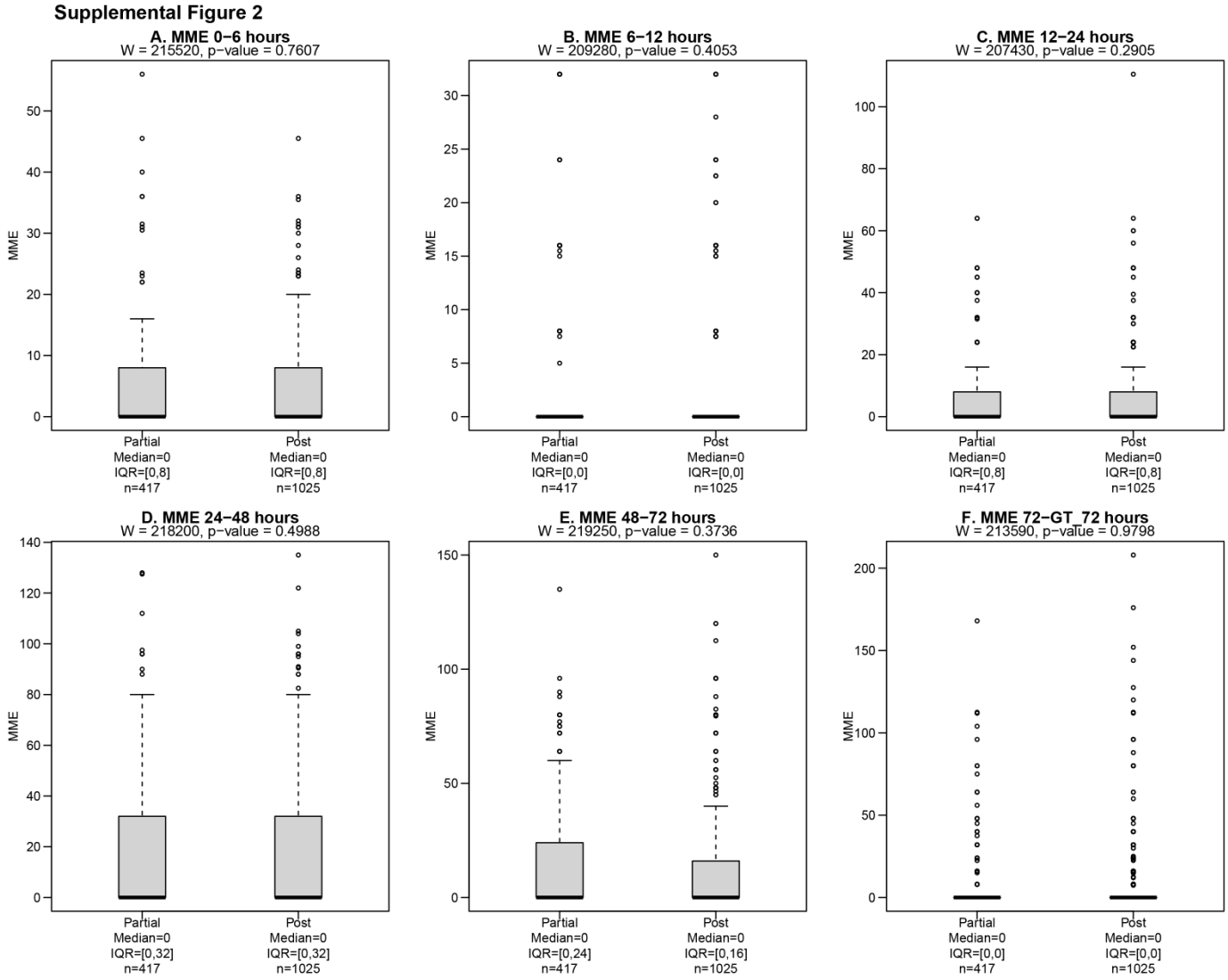
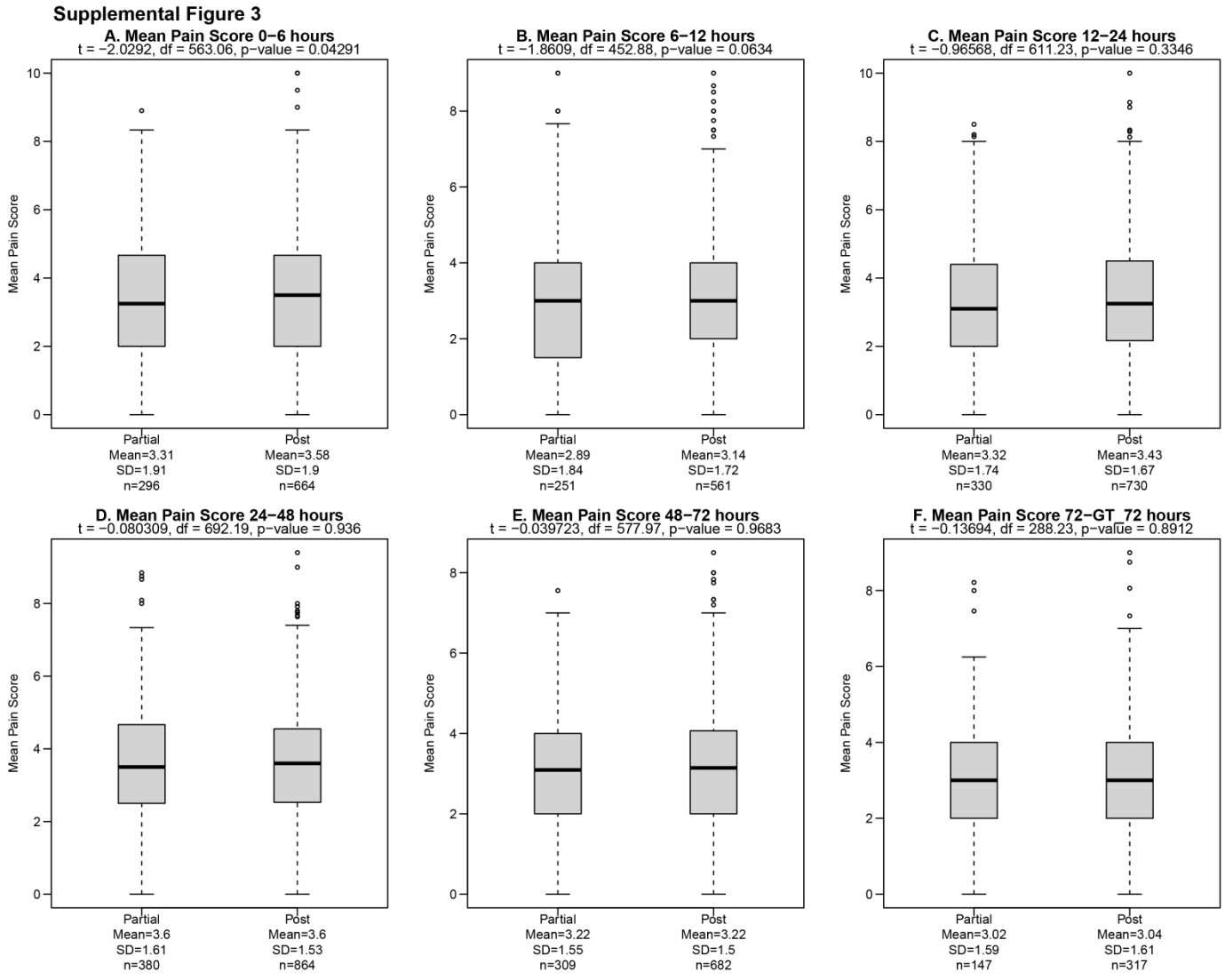
Supplemental Figure 1. Median cumulative MME utilization among the intrathecal morphine only and post-ERAS groups in (A) the first 6 hours post-cesarean, (B) the first 12 hours post-cesarean, (C) the first 24 hours post-cesarean, (D) the first 48 hours post-cesarean, (E) the first 72 hours post-cesarean, and (F) from cesarean until discharge from the hospital.



Supplemental Figure 2. Median MME among the partial-protocol and post-ERAS groups in the first (A) 0-6 hours post-cesarean, (B) 6-12 hours post-cesarean, (C) 12-24 hours post-cesarean, (D) 24-48 hours post-cesarean, (E) 48-72 hours post-cesarean, and (F) 72 hours post-cesarean until discharge.



Supplemental Figure 3. Mean pain scores among the partial-protocol and post-ERAS groups in the first (A) 0-6 hours post-cesarean, (B) 6-12 hours post-cesarean, (C) 12-24 hours post-cesarean, (D) 24-48 hours post-cesarean, (E) 48-72 hours post-cesarean, and (F) 72 hours post-cesarean until discharge.



Supplemental Figure 4. Median cumulative MME utilization among the pre-ERAS group and intrathecal morphine only (partial) groups in (A) the first 6 hours post-cesarean, (B) the first 12 hours post-cesarean, (C) the first 24 hours post-cesarean, (D) the first 48 hours post-cesarean, (E) the first 72 hours post-cesarean, and (F) from cesarean until discharge from the hospital.