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Early Post-Cesarean Anxiety, Nausea, Vomiting, and Pain Under Spinal Anesthesia: Trajectories and Modifiable Predictors

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Abstract

Recovery after caesarean under spinal anesthesia remains a quality gap, with scarce evidence on modifiable anesthetic practices improving recovery. Data linking the neuraxial technique, nausea, anxiety, and pain remain limited. The objective of this study was to describe postoperative nausea and vomiting, anxiety, and pain at 6, 12, and 24 hours after caesarean section under spinal anesthesia and to examine whether intrathecal adjuvant use, sensory block level, fasting duration, and American Society of Anesthesiologists (ASA) physical status were associated with these outcomes. Cross-sectional study across five hospitals; 534 women undergoing caesarean under spinal anesthesia. Exposures: intrathecal adjuvant, sensory level (≤ T6 and > T6), nil per os (NPO) time, and ASA class. Outcomes: postoperative nausea and vomiting (PONV) using Rhodes Index of Nausea, Vomiting, and Retching (RINVR), anxiety using State-Trait Anxiety-State STAI-S), pain at 6,12,24 h; generalized estimating equations Poisson and linear models. A total of 534 women completed the study (mean age, 31.8 years; mean body mass index, 29.3). Symptom burden was greatest in the early postoperative period: postoperative nausea and vomiting and pain were highest at 6 hours, whereas anxiety peaked at 12 hours. By 24 hours, symptoms had declined, although substantial proportions of women continued to report nausea and pain. Better ASA physical status (class I-II) was associated with lower RINVR and STAI-S. These findings suggest that modifiable perioperative factors may help inform strategies to improve early post-caesarean recovery and guide postoperative nursing monitoring and symptom management.

Keywords: anesthesia, anxiety, pain, post-operative caesarean section, postoperative nausea and vomiting, spinal anesthesia

Abstrak

Kecemasan, Mual, Muntah, dan Nyeri pada Masa Awal Pasca-Operasi Caesar dengan Anestesi Spinal: Pola Perkembangan dan Faktor Prediktor yang Dapat Dimodifikasi. *Pemulihan setelah operasi caesar dengan anestesi spinal masih menjadi kesenjangan mutu pelayanan dengan bukti yang terbatas mengenai praktik anestesi yang dapat dimodifikasi untuk meningkatkan pemulihan. Data menunjukkan bahwa keterkaitan antara teknik neuraksial, mual, kecemasan, dan nyeri masih terbatas. Penelitian ini bertujuan untuk mendeskripsikan kejadian mual dan muntah pascaoperasi, kecemasan, serta nyeri pada 6, 12, dan 24 jam setelah operasi sesar dengan anestesi spinal, serta menganalisis apakah penggunaan adjuvan intratekal, tingkat blok sensorik, durasi puasa, dan status fisik menurut* American Society of Anesthesiologists (ASA) *berhubungan dengan luaran tersebut. Studi potong lintang di lima rumah sakit pada 534 perempuan yang menjalani seksio sesarea dengan anestesi spinal. Paparan meliputi adjuvan intratekal, tingkat sensorik (≤ T6 dan > T6), lama nil per os (NPO), serta kelas ASA. Luaran meliputi* postoperative nausea and vomiting (PONV) *yang diukur menggunakan* Rhodes Index of Nausea, Vomiting, and Retching (RINVR), *kecemasan yang diukur menggunakan* State-Trait Anxiety-State (STAI-S), *dan nyeri pada 6, 12, dan 24 jam; analisis menggunakan model* generalised estimating equations Poisson *dan model linier. Sebanyak 534 perempuan menyelesaikan penelitian ini, dengan rerata usia 31,8 tahun dan rerata indeks massa tubuh 29,3. Beban gejala paling tinggi terjadi pada periode awal pascaoperasi: mual dan muntah pascaoperasi serta nyeri mencapai tingkat tertinggi pada 6 jam, sedangkan kecemasan*

memuncak pada 12 jam. Pada 24 jam pascaoperasi, gejala cenderung menurun, meskipun proporsi yang cukup besar dari partisipan masih melaporkan mual dan nyeri. Status fisik ASA *yang lebih baik (kelas I–II) berhubungan dengan skor* RINVR *serta* State-Trait-Anxiety (STAI) *yang lebih rendah. Temuan ini menunjukkan bahwa faktor perioperatif yang dapat dimodifikasi dapat memberikan masukan bagi pengembangan strategi untuk meningkatkan pemulihan dini pascaoperasi serta memperkuat pemantauan keperawatan pascaoperasi dan manajemen gejala.*

Kata Kunci: *anestesi, anestesi spinal, kecemasan, mual dan muntah pascaoperasi, nyeri, pascaoperasi seksio sesarea*

Introduction

Spinal anesthesia is used in the majority of women undergoing caesarean delivery; however, nausea or vomiting, anxiety, and pain may hinder early recovery by limiting mobilization, breastfeeding, and maternal satisfaction (Wilson et al., 2026). Preventing and early recognition of these symptoms are two of the four core quality targets promoted by Enhanced Recovery After Caesarean (ERAC) (Na, 2025). For now, there remains a paucity of time-dependent bedside data to inform hourly management of care in usual clinical practice (Walker et al., 2025). Recent Enhanced Recovery After Surgery (ERAS) guidelines have emphasized outcome-based metrics and highlighted the value of granular clinical data for developing pragmatic enhanced recovery pathway bundles (Sultan et al., 2025).

Worldwide, the uptake of caesarean section (CS) is approximately 21% and increasing, suggesting that at a population level, we should prioritize optimizing perioperative recovery (WHO, 2021). In this regard, recovery planning constitutes a central public health function. According to global estimates, by 2030, approximately 28.5% of births, or equivalent to 38 million caesarean deliveries per year, will be performed worldwide, which will vary between regions from 7.1% in sub-Saharan Africa to 63.4% in Eastern Asia (Betran et al., 2021). In Indonesia, the prevalence of CS rose from 1.6% in 1991 to approximately 17.6% in 2017, indicating a substantial increase, with nearly one in five births delivered by CS in 2017 (Zahroh et al., 2024). The estimated 260,000 maternal deaths in 2023 signal stagnating global progress and underpin the need for good-quality care at birth (WHO, 2025a). The maternal mortality rate in Indonesia is still high at around 140 per 100,000 live births, and thus the importance of improving immediate post-operative results should be emphasized (WHO, 2025b). Spinal-induced hypotension (SIH) is common during CS under spinal anesthesia and can occur in 60–80% of women without prophylaxis, with potential adverse effects on maternal comfort and fetal wellbeing (Higashi et al., 2025). Refractory SIH may lead to hemodynamic instability with presyncope, nausea, vomiting, and fetal acidosis, thereby linking physiological disturbances with maternal symptoms and neonatal outcomes of clinical relevance (Barud et al., 2025).

Evidence remains constrained by methodological choices that may obscure the dynamics of early symptoms. Most obstetric studies have described single-time estimates, rather than repeated fixed assessments within the initial 24 h (Hannola et al., 2021). Key modifiable exposures, including intrathecal adjuvants, target sensory level, and fasting practice, are commonly underreported or incompletely analyzed, limiting causal interpretation and the translation of findings into bedside practice (Singh et al., 2022). Moreover, definitions of SIH and the associated measurement windows vary across studies (Lorato et al., 2025), which limits comparability. Analyses testing time-by-covariate interactions remain limited, although they are important for identifying when specific factors are most relevant across the 6-, 12-, and 24-hour recovery trajectory (Ibrahem et al., 2024).

Although enhanced recovery strategies after CS are increasingly emphasized, evidence remains limited regarding symptom-based early recovery following spinal anesthesia. (Ibrahem et al., 2024; Na, 2025). Prior studies have mainly examined

overall quality of recovery, postoperative nausea and vomiting prophylaxis, or analgesic efficacy as separate outcomes rather than as concurrent trajectories of postoperative nausea and vomiting, anxiety, and pain during the first postoperative day (Hatter et al., 2025; Ishida et al., 2025; Wang et al., 2024). As a result, it remains unclear how these symptoms evolve across the 6-, 12-, and 24-hour postoperative periods and whether modifiable perioperative factors, particularly intrathecal adjuvant use, sensory block level, and fasting duration, are associated with these trajectories. This study aimed to address this gap by examining fixed early postoperative symptom trajectories and their associations with clinically relevant perioperative factors.

This study aimed to estimate the prevalence of postoperative nausea and vomiting at 6, 12, and 24 hours after CS under spinal anesthesia and to examine time-specific associations with potentially modifiable factors. It also provides a pragmatic multicenter assessment framework that may inform ERAC-aligned nurse-led recovery bundles in a middle-income setting.

Methods

Study Design and Setting. A multicenter hospital-based cross-sectional study with repeated postoperative assessments at 6, 12, and 24 hours was conducted among women undergoing CS under spinal anesthesia at five hospitals in Indonesia from July 3 to September 2025. Participating in hospitals were selected based on study feasibility, routine CS volume, and the ability to implement standardized postoperative assessments. Reporting followed the STROBE guideline (von et al., 2007).

Participants and Eligibility. Eligible participants were women aged 18 years or older undergoing CS under spinal anesthesia who were hemodynamically stable after surgery, able to provide written informed consent, and expected to remain hospitalized for at least 24 hours. Exclusion criteria were emergency CS when protocolized symptom assessment was not feasible, failed or converted spinal anesthesia, preoperative antiemetic or sedative exposure likely to affect anxiety assessment, severe psychiatric or communication disorders, postoperative intensive care unit transfer after the initial assessment, multiple pregnancy with major obstetric complications, and incomplete core questionnaire data. Participants were enrolled consecutively during the study period. A formal prospective sample size calculation was not prespecified. However, the final sample was considered adequate for the study objectives because cross-sectional studies commonly justify sample size based on prevalence precision (Charan & Biswas, 2013), and G*Power-based regression approximation supported adequacy for multivariable analysis (Faul et al., 2009; Kang, 2021). Methods specific to repeated-measures and generalized estimating equation designs are available and are preferable when prespecified at the design stage (Verbeeck et al., 2023). Using $\alpha = .05$, power = 0.90, $f^2 = 0.05$, and 14 predictor parameters, the minimum required sample size was estimated to be 473 participants, or 526 after allowing for 10% incomplete data. The final analytic sample of 534 women exceeded this threshold.

Outcomes and Measurements. Postoperative nausea and vomiting were assessed using the RINVR, an 8-item instrument with established reliability in postoperative patients, including Cronbach's α ranging from 0.912 to 0.968 (Kim et al., 2007). Because a formally validated Indonesian version was not available, the instrument was administered in Indonesian using harmonized interviewer scripts by trained nurses across all sites. State anxiety was assessed using the Indonesian-language STAI-S form, which has shown high reliability in prior Indonesian use, with Cronbach's α values of 0.940 for State-Trait-Anxiety (STAI) I and 0.905 for STAI II (Setiawati et al., 2021). Pain intensity was assessed using the NRS, an 11-point single-item measure that was also administered in Indonesian; prior Indonesian psychometric testing has shown excellent reliability, with Cronbach's alpha and intraclass correlation coefficient values greater

than 0.90 (Adha & Komalasari, 2024). All instruments were administered at 6 ± 1, 12 ± 1, and 24 ± 2 hours after surgery.

Exposures, Candidate Factors, and Confounders. Prespecified candidate factors were selected based on their clinical relevance to postoperative nausea and vomiting, anxiety, and pain. These factors included age, body mass index (BMI), duration of surgery, fasting duration, ASA physical status classification (American Society of Anesthesiologists [ASA], 2025), sensory block level, intrathecal adjuvant use, parity, history of previous surgery, and education level. Sensory block level was classified as at or below thoracic dermatome level 6 (T6) versus above T6, as assessed by pinprick. Age was grouped as younger than 20 years, 21–24 years, 25–29 years, 30–34 years, 35–39 years, and 40 years or older. BMI was categorized as less than 25 or 25 Kg/m^2 or higher. Duration of surgery was categorized as less than 30 minutes, 31–59 minutes, and 60 minutes or longer. Fasting duration was categorized as less than 2 hours, 2–3 hours, 4–5 hours, 6 hours, and more than 6 hours. Parity was classified as primiparous or multiparous, history of previous surgery as yes or no, and education level as high school or lower versus college or higher. ASA classification followed current professional guidance. Time-interaction terms were specified to assess whether sensory block level and intrathecal adjuvant use were associated with changes in symptom trajectories over time. ASA classification, education level, history of previous surgery, and study site were included as potential covariates.

Data Sources, Field Procedures, and Quality Control. Data were collected through bedside interviews and chart abstraction using a standardized electronic case-report form, which included built-in range checks and logic controls. We pretested the procedure to assess understanding, timing, and skipping patterns; enumerators underwent standardized training and certification with practice interviews and interrater verification. Site monitors conducted routine monitoring visits, query logs were kept, discrepancies were resolved, and time stamps were checked to determine whether assessments occurred within protocol windows; site and assessor information were retained to support clustered/robust variance estimation if required.

Efforts to Minimize Bias. Consecutive enrolment on all operating days within the study period and consistent selection criteria across sites were used to reduce selection bias. To reduce information bias, we used validated instruments, harmonized scripts, and fixed postoperative time windows (Gerbershagen et al., 2011; Kim et al., 2007; Tluczek et al., 2009). Confounding was addressed using a prespecified adjustment set and tests for potential interactions; we considered the use of cluster-robust standard errors when site-level clustering effects on variance were present. Leverage and Cook's distance were used to screen influential observations and outliers, and sensitivity analyses were performed after excluding influential observations and outliers.

Missing Data. We described the extent of missingness and patterns at different time points. When levels of missingness were greater than trivial, we performed multiple imputation by chained equations (MICE; m = 20) under a missing-at-random assumption, including outcomes and predictors and site in the imputation model and pooling estimates with Rubin's rules (Rubin, 1987; White et al., 2011) . Sensitivity checks were conducted and limited to complete-case analyses.

Statistical Analysis. We described characteristics as mean (SD) or median (IQR) and n (%). For binary prevalence outcomes at each timepoint, such as any postoperative nausea and vomiting (PONV), moderate-high anxiety, and moderate-severe pain, we calculated prevalence ratios (PRs) and their respective 95% confidence intervals (CIs) with the use of modified Poisson regression models using a robust variance estimation technique as primary analysis, and a log-binomial model for a specification check (Zou, 2004). For continuous secondary measures (RINVR, STAI-S, NRS), we conducted

linear regression and checked model assumptions, including normality, homoscedasticity, and linearity; when the assumptions were not met, we applied robust standard errors or appropriate transformation. Since symptoms were assessed at 6, 12, and 24 hours in each subject, we modelled trajectories using generalized estimating equations (GEE) with an identity link function, an exchangeable working correlation structure, robust (sandwich) variance estimators, prespecified categorical time point-by-covariate interaction terms, and reported coefficients with 95% confidence intervals and p values (Liang & Zeger, 1986). Model construction was based on a clinically informed full adjustment set; a condensed, purposeful-selection model was presented as a sensitivity analysis. We evaluated multicollinearity, using variance inflation factors (VIFs), with values < 10 considered acceptable, assessed potential non-linearity in continuous predictors using fractional polynomials or restricted cubic splines when appropriate, presented calibration/discrimination statistics where applicable, and applied cluster-robust standard errors when hospital-level clustering was likely to affect statistical inference; statistical significance was defined as $\alpha = 0.05$.

Ethical Consideration. The institutional review boards approved the protocol for this study in all the hospitals that had participated, which are Muhammadiyah Palembang Hospital (IRB No: B.LPPM-UHB/369/04/2025), Banjarnegara Islamic Hospital (IRB No: B.LPPM-UHB/553/06/2025), Fatimah Islamic Hospital (LPPM-UHB738/06/2025), Kebumen General Hospital (IRB No. B.LPPM-UHB/479/05/2025); and (IRB No. B.LPPM-UHB/610/06/2025). Written informed consent was obtained from all participants before data collection. The study was in accordance with the Declaration of Helsinki, and anonymized data were processed according to institutional regulations on information security.

Results

A total of 724 women were evaluated for eligibility across five hospitals. After exclusions for not receiving spinal anesthesia, refusal to provide consent, emergency status that precluded protocolized assessments, prohibited preoperative antiemetic use, psychiatric conditions or chronic sedative use that could invalidate STAI assessment, and failed spinal anesthesia, 573 women were recruited. An additional 39 women were excluded before analysis because of multiple gestation or significant obstetric exclusions (n = 18), incomplete key questionnaires (n = 2), missed 24-hour assessment (n = 8), or postoperative intensive care unit transfer (n = 11), resulting in an analytic sample of 534 participants (Figure 1).

In 534 consecutive post CS patients, the mean age was 31.8 ± 5 years, with the majority being 25-39 years old. Most were obese (87.6%, mean BMI 29.3 ± 3.8 kg/m²), ASA I (70.2%), multiparous (59%), operation duration about 60.8 ± 13.8 minutes, NPO duration about 4.0 ± 1.2 hours, and the majority had already received pre-operative information (61.6%) with SMP educational background. The incidence of PONV was extremely low (only 0-2 cases in each category) so that almost all patients were classified into the no-PONV group and no clear pattern of difference according to age, nutritional status, duration of operation, fasting duration, ASA status, the height of sensory block, the use of intrathecal adjuvant, history of operation, parity, education and educational status. While the proportion of moderate-high anxiety according to STAI was consistently higher compared to minimum-low anxiety, about 55-60% in most groups, and almost all patients had moderate-severe pain according to NRS, usually > 95%, with only a very small proportion reporting mild pain or no pain. Clinically, this profile indicates that patients were broadly similar in terms of demographic and perioperative characteristics, while the postoperative anxiety and pain burden was much more prominent than PONV, suggesting that quality-improvement efforts may prioritize optimized pain management and reduction of post CS anxiety (Table 1).

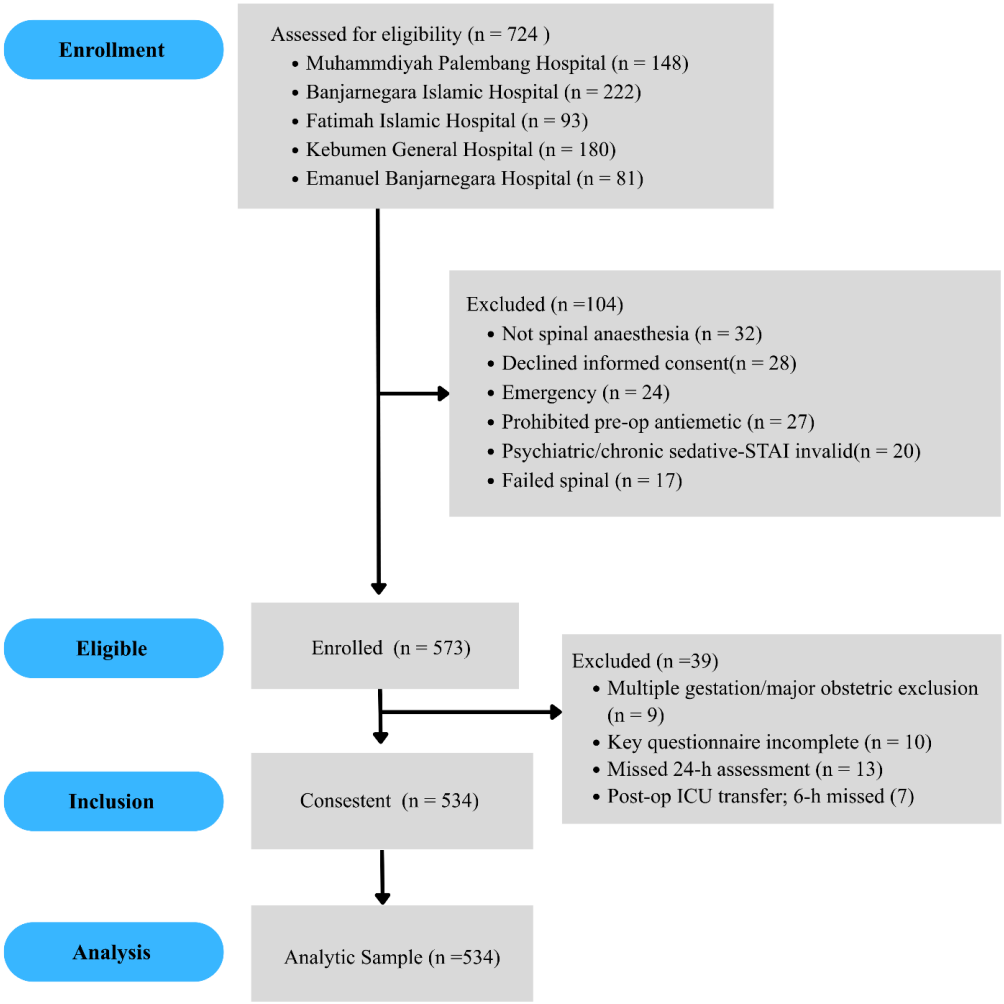

Figure 1. STROBE Flow Chart

Table 1. Clinical and Demographic Characteristics of Post-Cesarean Section Patients (N = 534)

Characteristics	Overall (534) n (%)	RINVR (n (%))		STAI (n (%))		NRS (n (%))	
		No PONV	PONV	Minimal to Low Anxiety	Moderate-High Anxiety	No to mild Pain	Moderate-Severe Pain
Age, years	31.82±4.96						
<20	7 (1.3)	0 (0)	7 (100)	4 (57.1)	3 (42.9)	0 (0)	7 (100)
21-24	27 (5.1)	0 (0)	27 (100)	10 37.0)	17 (63.0)	0 (0)	27 (100)
25-29	137 (25.7)	0 (0)	137 (100)	53 (38.7)	84 (61.3)	5 (3.6)	132 (96.4)
30-34	206 (38.6)	1 (0.5)	205 (99.5)	89 (43.2)	117 (56.8)	2 (1.0)	204 (99.0)
35-39	118 (22.1)	2 (99.5)	116 (98.3)	50 (42.4)	68 (57.6)	0 (0)	118 (100)
>40	39 (7.3)	0 (0)	39 (100)	12 (30.8)	27 (69.2)	0 (0)	39 (100)
BMI Kg/m^2	29.34±3.76						
>25 Obese	468 (87.6)	3 (0.6)	0 (0)	186 (39.7)	282 (60.3)	7 (1.5)	461 (98.5)
<25 Not Obese	66 (12.4)	465 (99.4)	66 (100)	32 (48.5)	34 (51.5)	0 (0)	66 (100)

Characteristics	Overall (534) n (%)	RINVR (n (%))		STAI (n (%))		NRS (n (%))	
		No PONV	PONV	Minimal to Low Anxiety	Moderate-High Anxiety	No to mild Pain	Moderate-Severe Pain
Duration of Operative	60.77±13.83						
<30 minutes	7 (1.3)	0 (0)	7 (100)	2 (28.6)	5 (71.4)	0 (0)	7 (100)
31-59 minutes	237 (44.4)	1 (0.4)	236 (99.6)	100 (42.2)	137 (57.8)	4 (1.7)	233 (98.3)
>60 minutes	281 (52.6)	1 (0.4)	280 (99.6)	110 (39.1)	171 (60.9)	3 (1.1)	278 (98.9)
Duration of Fasting	4.02±1.15						
<2 Hours	25 (4.7)	0 (0)	25 (100)	10 (40.0)	15 (60.0)	1 (4.0)	24 (96.0)
2-3 Hours	168 (31.5)	0 (0)	168 (100)	77 (45.8)	91 (54.2)	3 (1.8)	165 (98.2)
4-5 Hours	159 (29.8)	2 (1.3)	157 (98.7)	64 (40.3)	95 (59.7)	2 (1.3)	157 (98.7)
5-6 Hours	163 (30.5)	1 (0.6)	162 (99.4)	59 (36.2)	104 (63.8)	1 (0.5)	162 (99.4)
>6 Hours	19 (3.6)	0 (0)	19 (100)	8 (42.1)	11 (57.9)	0 (0)	19 (100)
ASA physical status						5 (1.3)	370 (98.7)
ASA I	375 (70.2)	2 (0.5)	373 (99.5)	149 (39.7)	226 (60.3)	2 (1.3)	157 (98.7)
ASA II	159 (29.8)	2 (0.6)	158 (99.4)	69 (43.4)	90 (56.6)		
Height of Sensory Block							
<T6	271 (50.7)	3 (1.1)	268 (98.9)	117 (43.2)	154 (56.8)	3 (1.1)	268 (98.9)
>T6	263 (49.3)	0 (0)	263 (100)	101 (38.4)	162 (61.6)	4 (1.5)	259 (98.5)
Intrathecal Adjuvant							
No	270 (50.6)	2 (0.7)	268 (99.3)	112 (41.5)	158 (58.5)	4 (1.5)	266 (98.5)
Yes	264 (49.4)	1 (0.4)	263 (99.6)	106 (40.2)	158 (59.8)	3 (1.1)	261 (98.7)
History Operative							
Yes	217 (40.6)	0 (0)	217 (100)	83 (38.2)	134 (61.8)	3 (1.4)	214 (98.6)
No	317 (59.4)	3 (0.9)	314 (99.1)	135 (42.6)	182 (57.4)	4 (1.3)	313 (98.7)
Number of Children	315 (59.0)	2 (0.6)	313 (99.4)	133 (42.2)	182 (57.8)	6 (1.9)	309 (98.1)
Multipara	219 (41.0)	1 (0.5)	218 (99.5)	85 (38.8)	134 (61.2)	1 (0.5)	218 (99.5)
Primipara							
Education Pre-operative							
No	205 (38.4)	1 (0.5)	204 (99.5)	90 (43.9)	115 (56.1)	3 (1.5)	202 (98.5)
Yes	329 (61.6)	2 (0.6)	327 (99.4)	128 (38.9)	201 (61.1)	4 (1.2)	325 (98.8)
Education Level							
High School	303 (56.7)	2 (0.7)	301 (99.3)	128 (42.2)	175 (57.8)	7 (2.3)	296 (97.7)
College	231 (43.3)	1 (0.4)	230 (99.6)	90 (39.0)	141 (61.0)	0 (0)	231 (100)

Note. ASA = American Society of Anesthesiologists Physical Status; n (%) = number (percentage); NRS -= Numeric Rating Scale; PONV = Postoperative Nausea and Vomiting; RINVR = Revised Index of Nausea, Vomiting, and Retching; SD = Standard Deviation; STAI = State-Trait Anxiety Inventory.

In 534 patients, we found only modest variation in anxiety over time, it was markedly greatest at 12 hours: moderate–high levels affected 74.7% (95% exact CI = 70.0 to 78.0), much more than at either 6 hours (40.8%, 37.0–45·0) or 24 hours later (35.4%, 31·0–40·0), whereas minimal to low

levels were least at this time-point (25.3%,22·0–29.0) compared with both the earlier and subsequent assessments after angiography; these differences are clear-statistically speaking(non-overlapping confidence intervals.) There was a progressive decrease in the proportion of patients even without PONV: 0.6% (0.0–2.0) at 6 h, 4.1% (3.0–6.0) at 12 h and 22.1% (18.0–26.0) at 24 h and with progressively fewer patients reporting only mild PONV for each subsequent time period on examination (99·4 to 95·9 to77·9%). It was a similar pattern for pain: normal–mild pain increased from 1.3% (0.6–2.7) at 6 hours to 7.5% (5.5–10.0) at 12 hours and then to 23.6% (20.2–27.4) at 24 hours, with the corresponding falls in moderate–severe pain (98.7% to 92.5% to 76.4%) (Table 2).

Overall, three time-by-covariate interactions were statistically significant. Firstly, for ASA I women, RINVR was significantly decreased at 12 h and 24 h compared to baseline (B = −1.427;95% CI: −2.300 -0.554; p = 0.001 and B −1.681, −2.489 to −0.873; p < 001 and B −1.482 (−2.360 to −0.603); p < 0.001) for ASA II compared to ASA I). BMW and B −1.685, −2.484 to −0.885; p < 0.001). Second, longer preoperative fasting duration was significantly associated with a lower RINVR score at 24 h (B = -0.103 per unit increase, 95% CI: -0.164 to -0.041; p = 0.001). All other time-by-covariate interactions were non-significant (Table 3

Table 2. Prevalence of STAI anxiety, RINVR PONV, and NRS pain categories at 6, 12, and 24 hours with 95% exact CIs (N = 534)

Proportion	6h n (%)	95% CI	12h n (%)	95% CI	24h n (%)	95% CI
STAI						
Minimal-Low	316 (59.2)	0.59 [0.54 to 0.63]	135 (25.3)	0.25 [0.22 to 0.29]	345 (64.5)	0.64 [0.60 to 0.68]
Moderate-High	218 (40.8)	0.41 [0.37 to 0.45]	399 (74.7)	0.74 [0.70 to 0.78]	189 (35.4)	0.35 [0.31 to 0.40]
RINVR						
No PONV	3 (0.6)	0.01 [0.00 to 0,02]	22 (4.1)	0.04 [0.03 to 0.06]	118 (22.1)	0.22 [0.18 to 0.26]
PONV Mild	531 (99.4)	0.99 [0.98 to 0.99]	512 95.9)	0.95 [0.93 to 0.97]	416 (77.9)	0.78 [0.74 to 0.81]
NRS						
Normal-Mild	7 (1.3)	1.3 [0.6 to 2.7]	40 (7.5)	7.5 [5.5 to 10.0]	126 (23.6)	23.6 [20.2 to 27.4]
Moderate - Severe	527 (98.7)	0.98 [0.97 to 0.99]	494 (92.5)	0.92 [0.89 to 0.94]	408 (76.4)	0.76 [0.72 to 0.79]

Note. 6 h / 12 h / 24 h: timepoints (hours) post-procedure; CI: Confidence Interval; n (%): number (percentage); NRS: Numeric Rating Scale; RINVR: Revised Index of Nausea, Vomiting, and Retching; STAI: State–Trait Anxiety Inventory.

Table 3. Time-by-covariate effects on RINVR 6h, 12h, and 24h

Effect (Baseline Time)	Contrast	Coefficient, B	95% CI	Wald χ^2	*p*
ASA I × Time (baseline)	6 h vs baseline	0.052	-0.128 to 0.231	0.321	0.571
	12 h vs baseline	-1.427	-2.300 to -0.554	10.272	0.001
	24 h vs baseline	-1.681	-2.489 to -0.873	16.636	< 0.001
ASA II × Time (baseline)	6 h vs baseline				
	12 h vs baseline	-1.482	-2.360 to -0.603	10.925	< 0.001
	24 h vs baseline	-1.685	-2.484 to -0.885	17.051	< 0.001

Effect (Baseline Time)	Contrast	Coefficient, B	95% CI	Wald χ^2	*p*
Sensory block height ≤ T6 × Time (baseline)	6 h vs baseline	-0.053	-0.219 to 0.112	0.398	0.528
	12 h vs baseline	-0.052	-0.220 to 0.116	0.364	0.546
	24 h vs baseline				
Sensory block height ≥ T6 × Time (baseline)	6 h vs baseline				
	12 h vs baseline				
	24 h vs baseline	-0.020	-0.171 to 0.131	0.066	0.798
Intrathecal adjuvant No × Time (baseline)	6 h vs baseline	-0.076	-0.244 to 0.092	0.789	0.374
	12 h vs baseline	-0.024	-0.194 to 0.145	0.079	0.779
	24 h vs baseline	-0.012	-0.164 to 0.139	0.025	0.875
Intrathecal adjuvant Yes × Time (baseline)	6 h vs baseline				
	12 h vs baseline				
	24 h vs baseline				
Age × Time (baseline)	6 h vs baseline	0.007	-0.023 to 0.010	0.658	0.417
	12 h vs baseline	< 0.001	-0.016 to 0.016	0.000	0.995
	24 h vs baseline	0.004	-0.012 to 0.019	0.226	0.635
BMI × Time (baseline)	6 h vs baseline	0.009	-0.011 to 0.030	0.808	0.369
	12 h vs baseline	0.007	-0.013 to 0.028	0.500	0.479
	24 h vs baseline	0.005	-0.025 to 0.014	0.291	0.590
Duration of operation × Time (baseline)	6 h vs baseline	0.003	-0.003 to 0.009	1.138	0.286
	12 h vs baseline	0.006	0.000 to 0.012	3.553	0.059
	24 h vs baseline	0.004	-0.001 to 0.010	2.224	0.136
Duration of fasting × Time (baseline)	6 h vs baseline	-0.050	-0.118 to 0.018	2.039	0.153
	12 h vs baseline	-0.015	-0.087 to 0.056	0.181	0.670
	24 h vs baseline	-0.103	-0.164 to -0.041	10.799	0.001

Note. 6 h / 12 h / 24 h: timepoints (hours) post-procedure; RINVR, Rhodes Index of Nausea, Vomiting, and Retching; GEE, generalized estimating equations; CI, confidence interval

Anxiety scores (STAI) remained significantly lower than baseline at all times after phase 1 was administered for women of ASA I and ASA II, and slightly higher at 12 h in those without intrathecal adjuvant. In particular, ASA I NF on 12 h was lower (B −7.17; p = 0.027) and 24 h (B −12.40; 95% CI −18.01 to −6.77; p < 0.001) and ASA II had similar declines at 12 h (B −7.45; 95% CI −13.77 to −1.12; p = 0.021) and the time 24 h (B −11.68; 95 % CI −17.42 to −5.94; p < 0.001). Conversely, absence of intrathecal adjuvant administration was associated with a greater increase in STAI score at 12 h postoperatively compared with the preoperative assessment (B 1.15; 95% CI 0.23 to 2.07; p = 0.014). No other time-by-covariate effects were significant (Table 4).

Only one interaction was associated with a change in pain over time. Women with a lower sensory block (≤ T6) reported slightly less pain at 6 hours than at baseline (B −0.284, 95% CI −0.512 to −0.057; p = 0.014). No other time-by-covariate terms showed evidence of an effect at 6, 12, or 24 hours. One interaction was associated with changes in pain over time. B women (with a lower sensory block ≤ T6) reported marginally less pain at 6 h compared with baseline (−0.284, 95% CI −0.512 to −0.057; p = 0.014). No other time-by-covariate terms were suggested to have a significant effect at 6, 12, or 24 hours (Table 5).

Table 4. Time-by-covariate effects on STAI 6 h, 12 h, and 24 h

Effect (reference)	Contrast	Coefficient, B	95% CI	Wald χ^2	*p*
ASA I × Time (baseline)	6 h vs baseline	-0.156	-1.08 to 0.775	0.107	0.743
	12 h vs baseline	-7.172	-13.53 to 0.810	4.881	0.027
	24 h vs baseline	-12.396	-18.01 to -6.77	18.690	< 0.001
ASA II × Time (baseline)	6 h vs baseline				
	12 h vs baseline	-7.446	-13.770 to -1.122	5.325	0.021
	24 h vs baseline	-11.677	-17.415 to -5.939	15.909	< 0.001
Sensory block height ≤ T6 × (baseline)	6 h vs baseline	-0.019	-0.936 to 0.898	0.002	0.968
	12 h vs baseline				
	24 h vs baseline	0.478	-0.401 to 1.356	1.136	0.287
Sensory block height ≥ T6 × Time (baseline)	6 h vs baseline	0.244	-0.632 to 1.121	0.299	0.585
	12 h vs baseline				
	24 h vs baseline				
Intrathecal adjuvant No × Time (baseline)	6 h vs baseline	0.779	-0.096 to 1.655	3.042	0.081
	12 h vs baseline	1.148	0.230 to 2.065	6.015	0.014
	24 h vs baseline	0.252	-0.638 to 1.141	0.308	0.579
Intrathecal adjuvant Yes × Time (baseline)	6 h vs baseline				
	12 h vs baseline				
	24 h vs baseline				
Age × Time (baseline)	6 h vs baseline	-0.044	-0.126 to 0.038	1.113	0.292
	12 h vs baseline	-0.062	-0.151 to 0.026	1.903	0.168
	24 h vs baseline	0.004	-0.099 to 0.082	0.034	0.854
BMI × Time (baseline)	6 h vs baseline	0.078	-0.186 to 0.030	1.982	0.159
	12 h vs baseline	0.016	-0.069 to 0.165	0.641	0.423
	24 h vs baseline	-0.005	-0.122 to 0.111	0.008	0.930
Duration of operation × Time (baseline)	6 h vs baseline	0.007	-0.025 to 0.039	0.200	0.654
	12 h vs baseline	0.012	-0.045 to 0.021	0.514	0.474
	24 h vs baseline	0.002	-0.035 to 0.030	0.022	0.883
Duration of fasting × Time (baseline)	6 h vs baseline	0.003	-0.380 to 0.374	0.000	0.987
	12 h vs baseline	-0.048	-0.432 to 0.336	0.061	0.805
	24 h vs baseline	0.343	-0.749 to 0.063	2.748	0.097

Abbreviations: 6 h / 12 h / 24 h: timepoints (hours) post-procedure; STAI, State–Trait Anxiety Inventory; GEE, generalized estimating equations; CI, confidence interval.

Table 5. Time-by-covariate effects on NRS 6h, 12h, and 24h

Effect (Baseline Time Level)	Contrast	Coefficient, B	95% CI	Wald χ^2	p
Age × Time (baseline time level)	6 h vs baseline	0.008	-0.016 to 0.032	0.463	0.496
	12 h vs baseline	0.017	-0.008 to 0.041	1.700	0.192
	24 h vs baseline	-0.016	-0.040 to 0.008	1.660	0.198
BMI × Time (baseline time level)	6 h vs baseline	-0.001	-0.028 to 0.027	0.002	0.962
	12 h vs baseline	-0.027	-0.059 to 0.006	2.603	0.107
	24 h vs baseline	-0.017	-0.047 to 0.013	1.216	0.270

Effect (Baseline Time Level)	Contrast	Coefficient, B	95% CI	Wald χ^2	p
Duration of operation × Time (baseline time level)	6 h vs baseline	-0.004	-0.013 to 0.004	0.965	0.326
	12 h vs baseline	-0.002	-0.010 to 0.006	0.231	0.631
	24 h vs baseline	0.002	-0.007 to 0.011	0.161	0.689
Duration of fasting × Time (baseline time level)	6 h vs baseline	0.065	-0.030 to 0.159	1.802	0.179
	12 h vs baseline	-0.023	-0.128 to 0.081	0.194	0.660
	24 h vs baseline	-0.058	-0.161 to 0.045	1.206	0.272
ASA I (vs ASA II) × Time (baseline time level)	6 h vs baseline	-1.238	-2.587 to 0.111	3.235	0.072
	12 h vs baseline	0.255	-1.768 to 1.258	0.109	0.741
	24 h vs baseline	-1.129	-2.481 to 0.223	2.678	0.102
Sensory block height ≤T6 (vs >T6) × Time (baseline time level)	6 h vs baseline	-0.284	-0.512 to 0.057	-5.996	0.014
	12 h vs baseline				
	24 h vs baseline	0.066	-0.173 to 0.305	0.289	0.591
Intrathecal adjuvant Yes (vs No) × Time (baseline time level)	6 h vs baseline	-0.025	-0.256 to 0.205	0.047	0.829
	12 h vs baseline				
	24 h vs baseline	0.039	-0.199 to 0.277	0.103	0.748

Note. 6 h / 12 h / 24 h: timepoints (hours) post-procedure; NRS, Numeric Rating Scale (pain); GEE, generalized estimating equations; CI, confidence interval.

Discussion

We observed that (1) healthier physiological status (ASA I-II) was associated with lower nausea or vomiting burden over time and lower anxiety at 12-24 h, (2) with longer pre-operative fasting we found slightly less nausea at 24 h, (3) no intrathecal adjuvant being used was associated with a small increment in anxiety at 12h, and (4) a reduced sensory block level (≤ T6), each after adjustment for prespecified covariates using repeated-measures models (-1.4 to -1.7 times greater likelihood of not vomiting during the RINVR assessment period from 2 to 24 h; ASA I; -7 to -12 points on STAI across the AMA period [ASA I–II]; +1.2 points on STAI, no adjuvant; and -0.28 cm NRS score [except for clonidine]) all p values < 0.03). Clinically, these patterns point to tolerable levers in a busy obstetric list, improving neuraxial technique (including adjuvants) and streamlining pre- operative preparation to decrease early symptom load following caesarean delivery. Provides detailed 6-, 12-, and 24-hour symptom profiles using validated tools (RINVR, STAI, and NRS) among women undergoing CS under spinal anesthesia, an area that remains underrepresented in obstetric ERAC pathways (Caballero-Lozada et al., 2022; Huh, 2023; Liu et al., 2025; Na, 2025). There are a number of potential mechanisms behind these observations.

Pregnancy-related physiology (progesterone-induced gastric hypomotility, delayed emptying) as well as neuraxial sympathectomy increase emetogenic risk, whereas multimodal antiemesis and careful dosing with intrathecal opioids may mitigate it (Kim et al., 2022; Wang et al., 2024). Intrathecal fentanyl enhances initial surgical analgesia and attenuates afferent nociception, possibly reducing conditioned anxiety at the 12-h zenith, while the absence of fentanyl enhances anxiety-pain interaction (Shebl et al., 2025). Differences in block height may affect the sensation of visceral traction and hemodynamic stability. A slightly lower block that remains adequate for surgery may contribute to early postoperative pain without causing discomfort in the upper sensory segments (Paliwal & Khan, 2025; Zhang et al., 2025). Alternative explanations may include residual confounding by unmeasured antiemetic timing, case urgency, or provider preference. Exposure misclassification is unlikely because sensory block level and intrathecal adjuvant use were

documented contemporaneously in the clinical record; less plausible because the time-varying symptom trajectories were anchored to the index anesthetic exposure.

Our time course is consistent with meta-analytic data that nausea and vomiting continues to be common around caesarean spinal anesthesia, and one that should be proactively prevented (Demilew et al., 2025; Huh, 2023). The correlation of intrathecal adjuvants with more favorable symptom profiles is in accordance with trials and meta-analyses, which have demonstrated that low-dose spinal opioids lower the incidence of PONV and increase analgesia, provided modern antiemetic prophylaxis is used to complement these (Hatter et al., 2025; Singh et al., 2022). The signal of fasting reduces 24-h nausea with prolonged fast, at odds with the recommendation from ERAC or ERAS practice, which promotes that patients receive the least short hours policy for clearance to clear-fluid defers, thus circumventing patient comfort and recovery (Na, 2025). This inconsistency may be due to the influence of unmeasured or residual covariates (e.g., antiemetic bundles, or the day of oral intake reintroduction) rather than a beneficial effect of prolonged fasting. Taken together, our findings extend previous work by characterizing symptom trajectories at fixed early postoperative time points and examining time-by-covariate effects for ASA class, fasting duration, intrathecal adjuvants, and sensory block level in routine care.

Except for the sensory-level effect, which was small and time-limited, across sensitivity checks in our longitudinal models, the direction and magnitude of effects were consistent: ASA I-II continued to be associated with lower RINVR and lower STAI at 12–24 h; the adjuvant–anxiety signal persisted at 12 h. Key internal threats in this study were: selection bias (elective versus semi-urgent patients); the possibility of information bias (symptom self-report and subjective benefit of treatments); and residual confounding, including antiemetic/analgesic timing and surgical difficulty. We addressed these limitations with prespecified covariates, repeated measures to reduce between-person variability, and standardized assessment time points. Current anesthesiology literature in obstetrics highlights similar bias regarding block level and neuraxial care interventions, with projected collection of sensory dermatome levels and prophylaxis components (Benjhawaleemas et al., 2024; Ravishankar et al., 2025; Rüggeberg et al., 2024). Its internal validity is adequate, and the relationships we observed seem robust (especially those with narrow 95% CIs that were model independent).

Our sample reflects real-world spinal anesthesia for caesarean delivery across multiple hospitals and a broad BMI distribution, with most patients ASA I-II and standard intrathecal techniques features common in many middle-income settings and increasingly similar to ERAC implementations globally (Ishida et al., 2025; Karataş et al., 2025; Na, 2025; Wilson et al., 2026). Generalization to centers with routine intrathecal morphine, universal dual-agent antiemetic prophylaxis, or robust antenatal education programs should account for these practice differences. Translation to high-resource ERAC programs may yield smaller absolute symptom burdens but similar relative associations; conversely, units with limited antiemetics or recovery staffing may see larger benefits from standardizing adjuvants and pre-op preparation (Ishida et al., 2025; Karataş et al., 2025; Wilson et al., 2026). Implementation should adapt to local formularies and workflows.

The cross-sectional repeated-measures design precludes causal inference regarding time-by-covariate effects; temporality is limited to the index anesthetic, and longitudinal counterfactual trajectories were not available. Symptom measures (RINVR, STAI, NRS) are validated but subjective; any non-differential misclassification will bias effects towards the null (and differential by anxiety or education would in either direction carry certain types of biases) (Huh, 2023; Kim et al., 2022; Liu et al., 2025; Zhang et al., 2025). Sampling across five hospitals increases the likelihood of capturing clinical

heterogeneity, but practice clusters (e.g., antiemetic protocols, or timing of oral intake) may dilute associations; although missingness at 24 h was modest, attenuated late-phase effects cannot be excluded if sicker patients were over-represented among non-responders. For the majority of these, some estimates might be conservative, potentially underestimating the effects of intrathecal adjuvants and ASA classification, although overestimation is also possible if provider preference was confounded by unmeasured supportive practices.

First, implantation of an off-the-shelf intrathecal adjuvant (e.g., low-dose fentanyl or morphine based on formulary) into a protocolized neuraxial bundle combined with dual-agent antiemetic prophylaxis for obstetric neuraxial opioids (Hatter et al., 2025; Singh et al., 2022; Wang et al., 2024; Wilson et al., 2026). Second, deploy ERAC-consistent fasting standards (solids until 6 h pre-op/clear fluids until 2 h, with surveillance of real-world fasting durations and early oral eating re-introduction; our "more lengthy fast - lower 24-hrq" sign-off should not trigger restrictive actions outside a randomized basis (Demilew et al., 2025; Na, 2025; Rüggeberg et al., 2024). Third, make a block-height checking routine (target T4-T6) and record sensory level/time for QI purpose documentation (Zhang et al., 2025). These actions are implementable within current systems of care and would likely lower symptoms for mothers and children and enhance early recovery.

Priorities would be pragmatic trials comparing standardized IT adjuvant bundles versus no adjuvants for spinal (patient-centered outcomes at 6-12-24 h), where hybrid effectiveness implementation designs could examine fidelity and scale-up costs (Benjhawaleemas et al., 2024; Hatter et al., 2025; Liu et al., 2025; Wilson et al., 2026). Longitudinal cohorts should examine how adherence to fasting recommendations and timing of oral intake interact with antiemetic bundles to shape symptom trajectories and breastfeeding success (Na, 2025; Rüggeberg et al., 2024). Mechanistic studies relating sensory-level dynamics to visceral discomfort and hemodynamics may explain early pain mechanisms (Zhang et al., 2025). Pathways that include pre-operative anxiety screening and focused education risk-stratified for the resulting combination of high-anxiety peaks and analgesic demands, deserve to be studied for impact on both peak levels of anxiety as well as analgesic requirements.

In the context of standard spinal anesthesia for caesarean delivery, symptom courses were more pronounced early after surgery but improved within 24 h; better ASA status, intrathecal adjuvant use and attention to sensory block level were associated with more favorable courses; a non-intuitive fasting signal should be interpreted cautiously. These results further endorse the use of protocolized neuraxial bundles and ERAC-appropriate preparation to mitigate early nausea, anxiety, and pain. The next step is pragmatic trials and implementation studies that can establish causality and identify scalable, resource-appropriate pathways.

This study has several limitations in design, measurement, data, analysis, and generalizability. The cross-sectional repeated-measures nature of our study (6, 12, 24 h after one anesthetic) means that we cannot establish causal relationships; this reflects real-world logistics as well as ethical considerations in obstetric care. All outcomes (RINVR nausea/vomiting, STAI anxiety, NRS pain) were self-reported, so measurement error and social desirability/recall bias are possible, which may attenuate true associations or, if reporting is correlated with unmeasured factors, exaggerate estimated effects. We were missing exact antiemetic timing/dose and rescue analgesia dose, as well as surgical complexity and provider preference details (residual confounding); 24-h missingness was modest or analyzed with complete cases; hence, there may be some bias. Some of the risks we controlled for with pre-specified covariates, standardized time points, validated tools, hospital-level quality control, and robust or clustered standard errors, and sensitivity checks. Effects were directionally consistent, but less precise in small sub-groups. Results will be most general-

izable to similar obstetric spinal cohorts, which lack universal intrathecal morphine and a defined antiemetic regimen; caution is appropriate when considering high-resource ERAC programs. Within such limitations, however, protocolized neuraxial adjuvants, standardized antiemetic bundles, and recording of sensory block level may represent practical targets for quality improvement. Altogether, subsequent research should consider multicenter longitudinal cohorts or pragmatic RCTs with validated exposure measures and rich covariate data, with sufficient power to investigate outcomes in the context of a core outcome set.

Conclusion

Early recovery after CS under spinal anesthesia was characterized by a substantial symptom burden, with postoperative nausea and vomiting and pain most prominent in the early postoperative period, and anxiety peaking at 12 h. More favorable symptom trajectories were observed among women with better American Society of Anesthesiologists physical status, intrathecal adjuvant use, and lower sensory block level, whereas the association with fasting duration should be interpreted cautiously. Given the cross-sectional design with repeated postoperative assessments, these findings should be interpreted as associations rather than causal effects. Nevertheless, the results may support structured perioperative care, including appropriate use of intrathecal adjuvants, standardized symptom monitoring at 6, 12, and 24 h, and close attention to modifiable perioperative factors such as sensory block level and fasting practices. These findings may help inform symptom-focused nursing care and protocolized postoperative recovery pathways after CS under spinal anesthesia. Further multicenter studies are needed to validate these findings and evaluate their generalizability across different clinical settings.

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Data Availability Statement

The data underlying this study are available from the corresponding author upon reasonable request, subject to institutional and ethical approval.

Author Contributions

Indah Susanti: Conceptualization, Methodology, Data Curation, Project Administration, Writing - Original Draft, and Writing - Review & Editing. **Eza Kemal Firdaus:** Investigation, Resources, Project Administration. **Septian Mirova Sebayang**: Formal Analysis, Validation, and Data Curation. **Amelia Andini:** Validation, Writing – Review and Editing. **Alicia Dumes Berg:** Investigation, Validation, and Writing - Review & Editing. **Margaret Atwood:** Literature Synthesis, Interpretation of Findings, Validation, and Writing - Review & Editing. **Rantiningsih Sumarni:** Investigation, Validation, Project Administration, and Review & Editing. **Mesya Mesya:** Investigation, Resources, and Data Curation. **Asmat Burhan:** Supervision, Conceptualization, Methodology, Formal Analysis, Validation, and Writing - Review & Editing.

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