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Intrathecal bupivacaine–opioid regimens for caesarean spinal anaesthesia: a retrospective cohort study in Windhoek, Namibia

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Intrathecal bupivacaine–opioid regimens for caesarean spinal anaesthesia: a retrospective cohort study in Windhoek, Namibia

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Keywords: spinal anaesthesia; caesarean delivery; bupivacaine; fentanyl; morphine; hypotension

Abstract

Intrathecal bupivacaine combined with opioids is widely used for spinal anaesthesia in caesarean delivery, but regimen choice may influence analgesia, haemodynamic stability and recovery. We conducted a retrospective cohort study of caesarean spinal anaesthesia records from one public and one private hospital in Windhoek, Namibia (2017–2025). Records were classified into six commonly used intrathecal bupivacaine–opioid regimens. Outcomes included pain, headache, nausea, shortness of breath, clinically documented sudden blood pressure drop (intraoperative and/or postoperative), backache and motor recovery grade. We fitted multivariable logistic regression models adjusted for age and body mass index (BMI), using plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg as the reference regimen. Of 400 records, 363 matched the six regimens. Mean age was 33.5 years (SD 5.9) and mean BMI was 30.2 kg/m² (SD 4.4). Compared with the reference regimen, hyperbaric bupivacaine 10 mg + fentanyl 30 µg and hyperbaric bupivacaine 8 mg + fentanyl 20 µg were associated with lower adjusted odds of pain (aOR 0.34, 95% CI 0.13–0.93; and aOR 0.40, 95% CI 0.19–0.85, respectively). Hyperbaric bupivacaine 10 mg + fentanyl 30 µg was associated with higher adjusted odds of sudden blood pressure drop (aOR 6.37, 95% CI 2.12–19.09). Backache was common (62.5% overall) and differed by regimen. In routine practice, intrathecal regimen selection was associated with pain, haemodynamic events and backache after caesarean spinal anaesthesia, supporting regimen and protocol optimisation that balances analgesia with haemodynamic risk.

Introduction

Spinal anaesthesia is the preferred technique for caesarean delivery due to its rapid onset, reliable surgical conditions, avoidance of airway instrumentation and reduced fetal exposure to systemic anaesthetics. [1,2] Its major limitation is maternal hypotension from sympathetic blockade causing arterial and venous vasodilation, reduced venous return and decreased cardiac output, compounded by aortocaval compression in the supine parturient. 1,3 Clinically significant hypotension is linked to nausea and vomiting and, if severe or prolonged, may impair uteroplacental perfusion and fetal acid–base status. [1,3]

Consequently, international evidence emphasises prevention and prompt treatment of spinal anaesthesia–mediated hypotension as central to safe obstetric anaesthesia. [1,3] Consensus guidance recommends prophylactic vasopressor infusions and structured haemodynamic targets for caesarean delivery under spinal anaesthesia, including in resource-limited settings. [12,13] Randomised trial evidence supports vasopressors as the cornerstone of prophylaxis and treatment: phenylephrine is widely used, while carefully prepared norepinephrine infusion strategies are increasingly adopted with appropriate monitoring. [14,15] Because prediction remains imperfect, a systematic review suggests baseline demographic factors alone have limited predictive utility, whereas dynamic tests and perfusion/volume indices may be more informative. [16]

In Southern Africa, pragmatic definitions and treatment thresholds for obstetric spinal hypotension have been proposed to support consistent practice and benchmarking. [13] In Namibia, evidence from Windhoek referral hospitals indicates that spinal anaesthesia–related hypotension remains common and may vary by clinical context (e.g., elective procedures) and maternal comorbidity, underscoring the need for optimised local protocols. [9] Local work has also compared vasopressor prophylaxis approaches such as phenylephrine bolus versus infusion. [10]

Hypotension risk is also influenced by the intrathecal regimen: higher local anaesthetic doses may intensify sympathetic blockade, whereas dose reduction can jeopardise surgical anaesthesia unless supported with adjuvants. [1,4] Intrathecal opioids are

therefore frequently combined with bupivacaine to enhance intraoperative analgesia, improve postoperative pain control and enable dose-sparing. [5,6] Network meta-analysis shows opioids are effective adjuncts, with morphine providing longer postoperative analgesia and fentanyl improving intraoperative comfort but increasing pruritus. [17]

Guidance supports intrathecal morphine (commonly 100–150 μg), often alongside a lipophilic opioid as part of multimodal postoperative strategies. [18,19] Systematic reviews of intrathecal fentanyl similarly demonstrate improved intraoperative analgesia with increased side effects (notably pruritus), and some studies report differences in nausea/vomiting depending on combinations and dose. [5,6] Compared with transversus abdominis plane block, intrathecal morphine offers comparable or superior analgesia but higher pruritus and postoperative nausea and vomiting, reinforcing careful dose selection and multimodal prophylaxis. [20] A recent noninferiority trial also suggests that increasing intrathecal bupivacaine dose can be noninferior to adding fentanyl, with lower pruritus when fentanyl is omitted. [21]

Neuraxial techniques may further affect maternal experience and service utilisation through post-dural puncture headache (PDPH) and postpartum backache. [7,8] PDPH risk relates to needle characteristics and number of attempts; multisociety guidelines provide structured recommendations for its prevention, diagnosis and management, supporting standardised postpartum follow-up. [22] Rising maternal overweight/obesity increases obstetric and anaesthetic complexity, making regimen optimisation particularly relevant in routine care. [11]

Despite extensive global evidence on vasopressors and intrathecal adjuvants, there is limited real-world comparative evidence from Namibia evaluating multiple routinely used intrathecal bupivacaine–opioid combinations across haemodynamic, analgesic and recovery outcomes in routine practice. [1,5,9]

Using routinely collected anaesthesia records from one public and one private hospital in Windhoek, Namibia (2017–2025), we compared postoperative outcomes across commonly used intrathecal bupivacaine–opioid regimens for caesarean spinal anaesthesia. Outcomes included pain, headache, nausea, shortness of breath, clinically

documented sudden blood pressure drop, backache and motor recovery grade, and associations were estimated using age- and BMI-adjusted multivariable models.

Methods

Study design and setting

We conducted a retrospective observational cohort study using routinely collected anaesthetic records for obstetric patients who underwent caesarean delivery under spinal anaesthesia between 2017 and 2025 in Windhoek, Namibia. Records were obtained from one public and one private hospital providing caesarean delivery services under spinal anaesthesia. The manuscript was prepared in accordance with the STROBE guideline for observational studies.

Study population

The source population comprised obstetric patients who received spinal anaesthesia for caesarean delivery during the study period and had an available anaesthetic record.

Inclusion criteria

Records were eligible if they (i) documented spinal anaesthesia for caesarean delivery within the study period and (ii) contained a clearly recorded intrathecal drug regimen that matched one of six predefined bupivacaine–opioid combinations.

Exclusion criteria

Records were excluded from comparative regimen analyses if the intrathecal regimen did not match any of the six predefined combinations. Such heterogeneous regimens were excluded to reduce exposure misclassification and to preserve interpretability of comparative estimates.

Exposure: intrathecal bupivacaine–opioid regimens

Participants were classified into six intrathecal regimen groups based on anaesthetic chart documentation of bupivacaine formulation (hyperbaric “heavy” or isobaric “plain”) and opioid adjuvants:

- *Regimen A:* Hyperbaric bupivacaine 10 mg + fentanyl 30 µg
- *Regimen B*: Hyperbaric bupivacaine 8 mg + fentanyl 20 µg
- *Regimen C:* Plain bupivacaine 7 mg + fentanyl 20 µg
- *Regimen D:* Plain bupivacaine 7 mg + morphine 0.4 mg
- *Regimen E*: Plain bupivacaine 8 mg + fentanyl 20 µg
- *Regimen F* (reference): Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg

Outcomes

Outcomes were extracted as recorded in routine postoperative documentation and included:

- *Pain* (present/absent)
- *Headache* (present/absent)
- *Nausea* (present/absent)
- *Shortness of breath* (present/absent)
- *Sudden blood pressure drop* (present/absent)
- *Backache* (present/absent)
- *Motor recovery grade* (ordinal grade 2–5, as recorded)

Operational note on blood pressure outcome

"Sudden blood pressure drop" was captured as a binary field in routine anaesthetic records and reflected clinical documentation rather than a standardized numeric definition. We therefore report this outcome as documented and interpret associations cautiously, noting potential variation in clinicians' thresholds for recording hypotension-related events.

Covariates

Age and body mass index (BMI) were included a priori as covariates in multivariable models. Additional peri-procedural variables available in the dataset (e.g., spinal needle gauge, number of attempts, block level, vasopressor use) were summarised descriptively and may be considered in secondary analyses where event counts allow stable estimation.

Statistical analysis

Continuous variables were summarised using means (standard deviations) and categorical variables using counts and percentages. Associations between regimen groups and categorical outcomes were assessed using chi-square tests, with Fisher's exact test considered when expected cell counts were small.

For each binary outcome, multivariable logistic regression models were fitted to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs), adjusting for age and BMI, with Regimen F specified a priori as the reference group. Motor recovery grade 2–5 was analysed using an ordinal logistic regression model adjusted for age and BMI, treating the outcome as ordered. All tests were two-sided with statistical significance set at $p < 0.05$. Analyses were conducted in Stata (version 12).

Sparse outcomes

Shortness of breath events were rare in the dataset; where sparse counts caused instability or non-convergence, outcomes were reported descriptively rather than modelled inferentially.

Missing data

Analyses used available data for each outcome. For example, shortness of breath had one missing observation (7/362 recorded) and denominators are reported accordingly.

Ethics

Ethics approval and consent to participate. This study involved a retrospective secondary analysis of routinely collected clinical/anaesthesia records from standard care. Eastgate

Clinic (Windhoek, Namibia) granted data custodian permission to access and analyse a de-identified dataset extracted from source records; direct identifiers were removed prior to analysis and reporting. An ethics exemption and waiver of individual informed consent were granted by the Eastgate Clinic Hospital Ethics Committee because the study used de-identified routine records and posed minimal risk to participants.

Results

Study Sample

A total of 400 anaesthetic records were available for review. Of these, 363 (90.8%) matched one of the six pre-specified intrathecal bupivacaine–opioid regimens (A–F) and were included in the comparative analyses; 37 (9.2%) records with heterogeneous intrathecal regimens were excluded from comparative modelling to preserve exposure homogeneity and interpretability.

Participant characteristics

Across the analytic sample (n = 363), the mean age was 33.49 years (SD 5.86) and the mean BMI was 30.23 kg/m² (SD 4.43). Regimen F (plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg) was the most frequently used (n = 175; 48.2%), followed by regimen B (n = 64; 17.6%) and regimen E (n = 61; 16.8%). Mean age and BMI varied across regimen groups **(Table 1).**

Table 1. Participant characteristics by intrathecal regimen

Group	Regimen	n	Age, mean (SD)	BMI, mean (SD)
A	Hyperbaric bupivacaine 10 mg + fentanyl 30 µg	39	31.33 (5.68)	30.17 (3.56)
B	Hyperbaric bupivacaine 8 mg + fentanyl 20 µg	64	33.72 (5.06)	30.58 (3.89)
C	Plain bupivacaine 7 mg + fentanyl 20 µg	15	34.40 (4.85)	28.49 (4.16)

D	Plain bupivacaine 7 mg + morphine 0.4 mg	9	30.67 (4.82)	34.91 (10.27)
E	Plain bupivacaine 8 mg + fentanyl 20 µg	61	32.07 (4.82)	30.87 (5.67)
F	Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg	175	34.45 (6.40)	29.80 (3.68)
Overall	All included regimens (A–F)	363	33.49 (5.86)	30.23 (4.43)

Outcome incidence by intrathecal regimen

Overall outcome incidence in the analytic sample was: pain 104/363 (28.7%), headache 74/363 (20.4%), nausea 50/363 (13.8%), shortness of breath 7/362 (1.9%), sudden blood pressure drop 23/363 (6.3%), and backache 227/363 (62.5%) **(Table 2).**

Pain incidence differed across regimens, ranging from 12.8% in regimen A (5/39) and 15.6% in regimen B (10/64) to 46.7% in regimen C (7/15) and 44.4% in regimen D (4/9). Sudden blood pressure drop was most frequent in regimen A (20.5%, 8/39) and absent in regimen C (0.0%, 0/15). Backache was common across all regimens, with the lowest proportion in regimen A (35.9%, 14/39) and the highest in regimens D (88.9%, 8/9) and C (86.7%, 13/15). Shortness of breath was rare (overall 7/362, 1.9%), with zero events in regimens A–C and more events recorded in regimen F.

Operational clarification: "Sudden blood pressure drop" was clinically documented in anaesthetic records and could reflect events occurring intraoperatively and/or during postoperative ward observation, rather than being anchored to a standard numerical threshold.

Table 2. Outcome incidence by intrathecal regimen

Group	Regimen	n	Pain	Headache	Nausea	SOB	BP drop	Backache

A	Hyperbaric bupivacaine 10 mg + fentanyl 30 µg	39	5/39 (12.8%)	10/39 (25.6%)	3/39 (7.7%)	0/39 (0.0%)	8/39 (20.5%)	14/39 (35.9%)
B	Hyperbaric bupivacaine 8 mg + fentanyl 20 µg	64	10/64 (15.6%)	10/64 (15.6%)	9/64 (14.1%)	0/63 (0.0%)	4/64 (6.2%)	38/64 (59.4%)
C	Plain bupivacaine 7 mg + fentanyl 20 µg	15	7/15 (46.7%)	3/15 (20.0%)	1/15 (6.7%)	0/15 (0.0%)	0/15 (0.0%)	13/15 (86.7%)
D	Plain bupivacaine 7 mg + morphine 0.4 mg	9	4/9 (44.4%)	1/9 (11.1%)	4/9 (44.4%)	1/9 (11.1%)	1/9 (11.1%)	8/9 (88.9%)
E	Plain bupivacaine 8 mg + fentanyl 20 µg	61	22/61 (36.1%)	6/61 (9.8%)	6/61 (9.8%)	1/61 (1.6%)	2/61 (3.3%)	46/61 (75.4%)
F	Plain bupivacaine 8 mg + fentanyl	175	56/175 (32.0%)	44/175 (25.1%)	27/175 (15.4%)	5/175 (2.9%)	8/175 (4.6%)	108/175 (61.7%)

	20 µg + morphine 0.6 mg							
Overall	All included regimens (A–F)	363	104/363 (28.7%)	74/363 (20.4%)	50/363 (13.8%)	7/362 (1.9%)	23/363 (6.3%)	227/363 (62.5%)

Abbreviations: SOB, shortness of breath; BP drop, sudden drop in blood pressure.

Bivariate comparisons

In bivariate analyses comparing outcome proportions across regimen groups **(Supplementary Table S1),** statistically significant differences were observed for pain ($p = 0.01$), sudden blood pressure drop ($p = 0.01$), and backache ($p < 0.001$). Differences were not statistically significant for headache ($p = 0.12$), nausea ($p = 0.07$), or shortness of breath ($p = 0.21$)

Supplementary Table S1. Bivariate comparisons across regimens (chi-square p-values)

Note: p-values are from chi-square tests comparing outcome proportions across regimen groups.

Multivariable associations

Pain

After adjustment for age and BMI (reference regimen: F), regimen A (hyperbaric bupivacaine 10 mg + fentanyl 30 µg) and regimen B (hyperbaric bupivacaine 8 mg + fentanyl 20 µg) were associated with lower odds of pain:

- Regimen A: aOR 0.34 (95% CI 0.13–0.93), $p = 0.04$
- Regimen B: aOR 0.40 (95% CI 0.19–0.85), $p = 0.02$ Regimens C, D, and E did not show statistically significant differences in adjusted odds of pain relative to regimen F.

Sudden blood pressure drop (clinically documented intra- and/or postoperatively)

After adjustment for age and BMI, regimen A was associated with increased odds of clinically documented sudden blood pressure drop:

- Regimen A: aOR 6.37 (95% CI 2.12–19.09), p = 0.01
- Estimates for smaller groups were imprecise; notably, regimen C had zero events, producing an unstable estimate consistent with complete separation.

Backache

After adjustment for age and BMI, backache differed by regimen:

- Regimen A: lower odds of backache, aOR 0.37 (95% CI 0.18–0.78), p = 0.01
- Regimen E: higher odds of backache, aOR 2.15 (95% CI 1.09–4.22), p = 0.03

Point estimates for regimens C and D suggested higher odds than regimen F, but confidence intervals were wide and did not reach conventional statistical significance, consistent with limited precision from small subgroup sizes.

Table 3. Adjusted odds ratios for pain (age and BMI adjusted)

Group	Regimen	Adjusted OR (95% CI)	p-value
A	Hyperbaric bupivacaine 10 mg + fentanyl 30 µg	0.34 (0.13–0.93)	0.04
B	Hyperbaric bupivacaine 8 mg + fentanyl 20 µg	0.40 (0.19–0.85)	0.02
C	Plain bupivacaine 7 mg + fentanyl 20 µg	1.87 (0.64–5.45)	0.25
D	Plain bupivacaine 7 mg + morphine 0.4 mg	1.90 (0.47–7.64)	0.37
E	Plain bupivacaine 8 mg + fentanyl 20 µg	1.29 (0.69–2.41)	0.43

Reference group: F (Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg).

Table 4. Adjusted odds ratios for sudden blood pressure drop (age and BMI adjusted)

Group	Regimen	Adjusted OR (95% CI)	p-value
A	Hyperbaric bupivacaine 10 mg + fentanyl 30 µg	6.37 (2.12–19.09)	0.01
B	Hyperbaric bupivacaine 8 mg + fentanyl 20 µg	1.50 (0.43–5.23)	0.52
C	Plain bupivacaine 7 mg + fentanyl 20 µg	0.00 (0.00–∞)	1.00
D	Plain bupivacaine 7 mg + morphine 0.4 mg	3.76 (0.38–36.76)	0.26
E	Plain bupivacaine 8 mg + fentanyl 20 µg	0.82 (0.17–4.05)	0.81

Reference group: F (Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg).

Note: The estimate for regimen C reflects zero events in that group and should be interpreted cautiously.

Table 5. Adjusted odds ratios for backache (age and BMI adjusted)

Group	Regimen	Adjusted OR (95% CI)	p-value
A	Hyperbaric bupivacaine 10 mg + fentanyl 30 µg	0.37 (0.18–0.78)	0.01
B	Hyperbaric bupivacaine 8 mg + fentanyl 20 µg	0.96 (0.53–1.73)	0.88
C	Plain bupivacaine 7 mg + fentanyl 20 µg	3.82 (0.83–17.54)	0.09
D	Plain bupivacaine 7 mg + morphine 0.4 mg	7.57 (0.86–66.78)	0.07
E	Plain bupivacaine 8 mg + fentanyl 20 µg	2.15 (1.09–4.22)	0.03

Reference group: F (Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg).

Motor recovery grade

Motor recovery was predominantly Grade 4 (n = 185) and Grade 3 (n = 122), with fewer Grade 2 (n = 30) and Grade 5 (n = 26). In the age- and BMI-adjusted ordinal logistic regression, none of the regimen groups differed significantly from regimen F in the odds

of being in a higher motor recovery grade; age and BMI were also not independently associated with motor recovery grade. **(Supplementary Table S2)**

Supplementary Table S2. Ordinal logistic regression for motor recovery grade (higher grade) (age and BMI adjusted).

Reference regimen for regimen predictors is F (Plain bupivacaine 8 mg + fentanyl 20 µg + morphine 0.6 mg). OR > 1 indicates higher odds of being in a higher motor recovery grade

Model stability and rare outcomes

Rare outcomes and missingness

Shortness of breath was rare (7/362) and occurred in only a subset of regimen groups; because of sparse event counts and multiple zero-event cells, it was reported descriptively rather than modelled inferentially. One observation was missing for shortness of breath, and denominators reflect available data **(Tables 2 and 5).**

Discussion

Principal findings

Using routinely collected anaesthesia records from one public and one private hospital in Windhoek, we identified clinically meaningful differences in postoperative outcomes across six commonly used intrathecal bupivacaine–opioid regimens for caesarean spinal anaesthesia. Specifically, hyperbaric bupivacaine regimens supplemented with fentanyl (regimens A and B) were associated with lower odds of pain, while the higher-dose hyperbaric regimen (A: hyperbaric bupivacaine 10 mg + fentanyl 30 µg) was associated with higher odds of clinically documented sudden blood pressure drop. Backache was highly prevalent overall and differed by regimen, whereas motor recovery grade did not differ significantly after adjustment for age and BMI. Interpreted as a QI evaluation, these findings highlight modifiable practice variation (choice of intrathecal regimen) that may influence patient-centred outcomes and haemodynamic stability in routine care.

Analgesia findings in a real-world/QI context

The lower adjusted odds of pain with hyperbaric bupivacaine plus fentanyl regimens are consistent with broader evidence that intrathecal fentanyl improves perioperative analgesic conditions in caesarean delivery, including reduced intraoperative supplementation and improved comfort in multiple trials and evidence syntheses. [5,6,17,19] Our results also align with the principle that opioid adjuncts provide dose-sparing and analgesic enhancement, with morphine contributing longer postoperative analgesia and fentanyl improving intraoperative comfort, albeit with differing side-effect profiles across studies. [17–19]

From a QI perspective, it is notable that pain remained common even in the reference regimen (plain bupivacaine 8 mg + fentanyl 20 μg + morphine 0.6 mg). Routine documentation often captures "pain" as a binary presence/absence field without standardised timing or validated scales, and this can dilute comparisons relative to controlled trials. Even so, the consistent directional signal (lower pain with fentanyl-containing hyperbaric regimens) suggests that regimen selection is a practical lever for improving analgesic experience, and it supports the value of standardising postoperative pain assessment and documentation as part of perioperative QI. [19]

Haemodynamic outcomes and quality measurement: "sudden blood pressure drop"

Spinal anaesthesia–induced hypotension remains a major limitation in caesarean delivery, driven by sympathetic blockade and exacerbated by aortocaval compression, and is associated with clinically important maternal symptoms and potential fetal compromise when severe or prolonged. [1–3,23] The higher odds of clinically documented sudden blood pressure drop with the higher-dose hyperbaric regimen (A) is therefore physiologically plausible and coherent with evidence that intrathecal dose and block intensity can influence hypotension risk. [1–4]

However, for QI interpretation, the most important nuance is measurement: in this study, "sudden blood pressure drop" was recorded as a clinically documented binary outcome and could include events observed intraoperatively and/or in the postoperative ward, rather than being anchored to a uniform numeric definition. This approach reflects

how real-world practice records haemodynamic instability but introduces variability in clinicians' thresholds and time windows for recording events. Similar challenges have motivated calls, particularly in resource-limited settings, for pragmatic consensus definitions of obstetric spinal hypotension to enable benchmarking and consistent reporting. [13]

The implication for perioperative QI is twofold. First, regimen choice should be aligned with haemodynamic prevention strategies that have substantial evidence support, including prophylactic vasopressor approaches. [3,12,14,15,25] Second, haemodynamic QI metrics are strengthened when documentation uses explicit thresholds and time windows (e.g., SBP <90 mmHg or ≥20% fall from baseline within defined intraoperative and early postoperative periods), improving interpretability across providers and over time. [12,13]

Local Windhoek evidence underscores the relevance of this QI framing: hypotension under spinal anaesthesia has been reported as common in Windhoek referral hospitals, and efforts to optimise prophylaxis strategies (e.g., phenylephrine bolus versus infusion) illustrate active protocol improvement opportunities in the same context. [9,10]

Backache: high-burden patient-centred outcome and documentation opportunity

Backache was documented in nearly two-thirds of cases, making it one of the largest patient-centred burdens identified in routine records. Postpartum backache following neuraxial techniques is often multifactorial, and neuraxial morbidity frameworks emphasise procedural influences (needle gauge/type, puncture attempts) and postpartum symptom syndromes that can overlap with headache/back pain reporting. [7,22] Professional statements and consensus guidance on post-dural puncture headache management further highlight the value of structured postpartum assessment and follow-up, which can be adapted into local postoperative symptom documentation to support QI. [8,22]

Because backache was captured as a binary field without severity, timing, or functional impact, regimen-related differences should be interpreted cautiously as they may reflect documentation practices, changes in care processes, or unmeasured

procedural difficulty rather than direct pharmacologic effects. Nonetheless, the high prevalence makes backache a priority QI endpoint: standardised symptom assessment (timing, severity, impact), alongside procedural covariates (needle gauge/type, number of attempts), could help distinguish musculoskeletal postpartum pain from neuraxial-related symptom complexes and identify actionable drivers. [7,22]

Other outcomes, rare events, and motor recovery

We did not detect statistically significant between-regimen differences for headache or nausea in bivariate comparisons, and shortness of breath was too rare for reliable modelling. Sparse event counts and multiple zero-cell structures in routine datasets commonly limit inferential precision and should be addressed transparently, as done here by descriptive reporting when modelling is unstable. Motor recovery grade also did not differ significantly after adjustment; this may reflect similar motor recovery profiles across regimens in routine practice or limited sensitivity of the recorded grading scale to detect subtle differences.

Strengths and limitations

A key strength is pragmatic external validity: the study spans multiple years, includes both public and private hospital practice, and evaluates regimen variation as it occurs in routine care, features that are central to perioperative QI evaluation. Pre-specifying regimen groups and excluding heterogeneous regimens also strengthened interpretability by reducing exposure heterogeneity.

Limitations include the retrospective observational design, which limits causal inference and introduces potential confounding by unmeasured factors (case urgency, baseline haemodynamics, fluid/vasopressor strategies, provider preference). Outcome measurement relied on routine chart fields: several outcomes were binary and non-standardised, and “sudden blood pressure drop” was clinician-documented across intraoperative and postoperative contexts without a numeric definition, limiting comparability to studies using strict hypotension thresholds. Small subgroup sizes for some regimens (notably C and D) reduced precision and created separation issues for outcomes with zero events in some cells.

Implications for perioperative QI and future research

These findings support a balanced QI approach to regimen optimisation: hyperbaric bupivacaine with fentanyl may improve analgesic outcomes, but higher-dose hyperbaric regimens may increase haemodynamic risk, underscoring the need to align regimen selection with evidence-based haemodynamic prevention strategies. [1–4,12,14,15,25] In Windhoek, where hypotension is recognised as common, targeted protocol refinement (including vasopressor strategy optimisation) may yield measurable improvements in maternal outcomes. [9,10]

Future work should prioritise strengthening QI measurement validity: adopting standard hypotension definitions and time windows, implementing validated pain assessments or analgesic consumption endpoints, and systematically capturing procedural and management covariates (needle characteristics, attempts, block height, vasopressor/fluid strategies). [12,13,19,22] Prospective designs or stepped implementation evaluations could then better attribute outcome changes to specific regimen/protocol modifications while preserving real-world relevance

Conclusion

In this cohort of caesarean deliveries under spinal anaesthesia, intrathecal bupivacaine–opioid regimen selection was associated with clinically important differences in postoperative outcomes. Hyperbaric bupivacaine regimens supplemented with fentanyl (regimens A and B) were associated with lower odds of pain compared with the reference regimen (F), while the higher-dose hyperbaric regimen (A) was associated with increased odds of sudden blood pressure drop. Backache was common overall and differed by regimen, with lower odds in regimen A and higher odds in regimen E relative to regimen F. Motor recovery grade did not differ significantly between regimens after adjustment for age and body mass index, and shortness of breath was too rare for reliable modelling.

These findings suggest that regimen choice may improve analgesia but requires careful balancing against haemodynamic risk. Context-specific protocol optimisation—

particularly aligning intrathecal dosing with proactive haemodynamic prevention strategies, may improve patient outcomes in routine obstetric practice.

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Competing interests

The authors declare no competing interests.

Author contributions

Talent Farai Mafumhe: Conceptualisation; data curation; investigation; project administration; writing – original draft; manuscript finalisation.

Hamufare Dumisani Mugauri: Methodology; formal analysis; validation; interpretation of findings; writing – original draft; writing – review and editing; manuscript finalisation.

Samuel Oluwaseun Olojede: Methodology input; literature synthesis; writing – review and editing.

Vonai Charamba: Data management support; writing – review and editing.

Ayoola Isaac Jegede: Methodology input; writing – review and editing.

Onyemaechi Okpara Azu: Supervision; conceptualisation; methodology; interpretation of findings; writing – review and editing; final approval of the manuscript.

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Data availability

The de-identified dataset analysed during the current study is available from the corresponding author on reasonable request, subject to data custodian permission from Eastgate Clinic and any applicable institutional requirements.

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