

The Nonlinear Relationship Between Maternal Temperature Variation and Total Duration of Labor: A Cross-Sectional Study of 6,654 Parturients with Epidural Analgesia

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Abstract

Background

Epidural analgesia is associated with maternal hyperthermia during labor, but the relationship between temperature variation and labor progression remains unclear. This study aimed to investigate the association between maternal temperature change and total duration of labor in parturients receiving epidural analgesia.

Methods

This cross-sectional study included 6,654 parturients who received epidural analgesia for vaginal delivery at Maternity&Child Healthcare Hospital of Longgang District, Shenzhen City in 2024. Generalized additive models and two-piecewise linear regression were employed to examine the dose-response relationship and threshold effects. Subgroup analyses were performed by parity and oxytocin use.

Results

A nonlinear, inverted U-shaped relationship was identified between temperature variation and total labor duration, with an inflection point at 1.2°C. Below this threshold, each 0.1°C increment in temperature variation was significantly associated with prolonged labor ($\beta = 17.4$ min, 95% CI: 14.6 to 20.3, $P < 0.001$). Above 1.2°C, further temperature elevation was significantly associated with shorter labor duration ($\beta = -8.0$ min, 95% CI: -13.6 to -2.4, $P = 0.005$). The two-piecewise model provided superior fit compared to linear models (P for log-likelihood ratio < 0.001).

Conclusions

Intrapartum temperature variation exhibits a nonlinear, threshold-dependent relationship with labor duration in women receiving epidural analgesia.

Background

Labor pain is a significant clinical challenge, driving a long-standing quest to optimize analgesia without compromising maternal or neonatal outcomes(1). Epidural analgesia has become one of the most widely used modalities for pain relief during labor, with adoption spanning a broad range of obstetric settings and patient populations(1). Contemporary practice data indicate that neuraxial techniques are employed in a majority of parturients in many centers, reflecting both analgesic efficacy and favorable safety profiles when implemented with standardized protocols(1, 2). However, neuraxial labor analgesia, and particularly epidural analgesia, is consistently associated with an increased risk of maternal intrapartum fever, a phenomenon commonly referred to as epidural-related fever (ERF), compared to

labor without analgesia or with non-neuraxial techniques(3–8). Intrapartum fever is associated with adverse clinical consequences, including increased rates of neonatal sepsis evaluations and antibiotic exposure, altered maternal and neonatal management decisions, and potential disruption of labor progression and obstetric outcomes(5, 7, 9).

Beyond the immediate consequences of fever itself, prolonged labor represents an independent risk factor for adverse outcomes. Extended labor durations have been linked to higher risks of postpartum hemorrhage, perineal trauma, and cesarean delivery, as well as increased neonatal morbidity including respiratory complications and NICU admission(10–12). Despite the well-documented coexistence of epidural use, fever, and labor progression, the direct relationship between intrapartum temperature dynamics and the length of labor remains poorly understood and inconsistently reported.

Existing studies have yielded different conclusions. While some investigations suggest that fever is associated with prolonged labor—potentially mediated by underlying infection, inflammation, or impaired uterine contractility—others indicate that non-infectious ERF does not necessarily extend labor duration (7, 13–15). Notably, most existing studies have treated temperature as a categorical variable (fever vs. no fever) or view the relationship between temperature and duration of labor as linear. Such analytical approaches may obscure more complex, nonlinear, or threshold-dependent relationships between subtle changes in maternal temperature and labor progression.

Therefore, this large-sample, cross-sectional study aimed to investigate the relationship between the temperature variation and total labor duration in women receiving epidural analgesia. Specifically, we sought to determine whether this relationship follows a nonlinear pattern and to identify any potential threshold effect that could inform more nuanced clinical management of labor and fever.

Methods

Study Design and Population

This was a cross-sectional study in which data were extracted from parturients who received epidural analgesia during vaginal delivery at Maternity&Child Healthcare Hospital of Longgang District, Shenzhen City in 2024. The study was approved by the Institutional Review Board, and the requirement for informed consent was waived due to the retrospective nature of the analysis.

Inclusion criteria were: (1) cephalic presentation, (2) spontaneous or induced labor, and (3) epidural analgesia administered during labor. Exclusion criteria included: (1) admission body temperature $\geq 37.3^{\circ}\text{C}$, (2) age < 18 years old, (3) incomplete temperature records, (4) incomplete temperature or labor duration records, and (5) incomplete labor duration records.

Data Collection

Demographic and Clinical Data: Maternal demographic and clinical data were extracted from electronic medical records, including age, body mass index (BMI), educational level, ethnicity, gravidity, parity, gestational age, obstetric history, and medical comorbidities (gestational hypertension, gestational diabetes).

Temperature Measurements: Temperature was measured using axillary thermometers according to institutional protocol. Baseline temperature was defined as the first temperature measured upon hospital admission. Maximum temperature during labor was the highest temperature recorded from admission until delivery. Temperature variation was calculated as maximum temperature minus baseline temperature.

Labor Characteristics: Total duration of labor was defined as the interval from the onset of regular uterine contractions (≥ 2 contractions per 10 minutes) to delivery.⁽¹⁶⁾ Use of oxytocin augmentation during labor was recorded.

Laboratory Parameters: The following laboratory parameters, measured upon admission, were collected: white blood cell count, hemoglobin concentration, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count, and absolute monocyte count.

Statistical Analysis

Continuous variables were described as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR) based on their distribution. Categorical variables were presented as numbers and percentages. Baseline characteristics were compared between the low ($< 36.6^{\circ}\text{C}$) and high ($\geq 36.6^{\circ}\text{C}$) admission body temperature groups using Student's t-test for continuous variables and chi-square test for categorical variables.

To identify factors associated with the total duration of labor, univariate linear regression analyses were first performed for each baseline variable. Results were presented as β coefficients with 95% confidence intervals (CIs).

We employed a generalized additive model (GAM) to explore the dose-response relationship between temperature variation and the total duration of labor, which revealed a non-linear pattern. To further characterize this non-linear relationship, we constructed a two-piecewise linear regression model to examine the threshold effect of temperature variation on labor duration. The inflection point (turning point) was determined using a trial-and-error approach, where the candidate turning point was moved along a pre-specified interval, and the value maximizing the model likelihood was selected.

Three multivariable models with progressive levels of adjustment were constructed to assess the robustness of the association. Model 1 was adjusted for age only. Model 2 was further adjusted for body mass index, education level, ethnicity, use of oxytocin during labor, hypertensive disorders of pregnancy, gestational diabetes mellitus, gravidity, parity, and gestational age. Model 3 was additionally adjusted for

laboratory parameters, including white blood cell count, hemoglobin, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count, and absolute monocyte count. To compare the goodness-of-fit between the one-line linear regression model and the two-piecewise linear model, we performed log-likelihood ratio tests. A P-value < 0.05 indicated that the two-piecewise linear model provided a significantly better fit, supporting the presence of a threshold effect.

Subgroup analyses were performed to investigate whether the association between temperature variation and total labor duration varied by potential effect modifiers. Participants were stratified by parity (primiparous vs. multiparous) and using oxytocin during labor (yes vs. no). In each subgroup, the two-piecewise linear regression model was refitted using the same inflection point (1.2°C) identified in the main analysis, with full adjustment for all covariates in Model 3 (except the stratification variable itself). Log-likelihood ratio tests were used to compare the two-piecewise model with the linear model within each subgroup.

All statistical analyses were performed using EmpowerStats (www.empowerstats.com, X&Y Solutions, Inc., Boston, MA) and R software version 4.2.0 (R Foundation for Statistical Computing, Vienna, Austria). A two-tailed P-value < 0.05 was considered statistically significant.

Results

Study population

A total of 7,577 parturients who received labor analgesia in 2024 were initially enrolled. We sequentially excluded those with an admission body temperature $\geq 37.3^{\circ}\text{C}$ (n = 8), age < 18 years (n = 9), incomplete temperature records (n = 19), gestational age < 37 weeks (n = 337), and incomplete labor duration records (n = 550). After applying these exclusion criteria, a final cohort of 6,654 parturients was included in the analysis (Fig. 1).

Baseline characteristics

The study included a total of 6,654 participants, who were stratified into two groups based on the median admission body temperature (low temperature group: $< 36.6^{\circ}\text{C}$, n = 2,872; high temperature group: $\geq 36.6^{\circ}\text{C}$, n = 3,782) (Table 1). While maximum body temperature was similar ($36.99 \pm 0.40^{\circ}\text{C}$ vs. $36.99 \pm 0.37^{\circ}\text{C}$, P = 0.711), temperature variation was significantly greater in the low-temperature group ($0.54 \pm 0.41^{\circ}\text{C}$ vs. $0.30 \pm 0.39^{\circ}\text{C}$, P < 0.001). Regarding baseline characteristics, the low temperature group had a slightly, but significantly higher body mass index (BMI) compared to the high group ($21.64 \pm 3.21 \text{ kg/m}^2$ vs. $21.46 \pm 3.08 \text{ kg/m}^2$, P = 0.023). Furthermore, the prevalence of hypertensive disorders of pregnancy was significantly lower in the low group than in the high group (1.29% vs. 2.33%, P = 0.002). No significant differences were observed between groups for other continuous variables, including total duration of labor, age, gestational age, white blood cell count, hemoglobin, platelet count, and absolute

counts of neutrophils, lymphocytes, eosinophils, basophils and monocytes (all $P > 0.05$). Similarly, categorical variables such as education level, ethnicity, use of oxytocin during labor, gestational diabetes mellitus, gravidity, and parity did not differ significantly between groups (all $P > 0.05$).

Table 1
Baseline characteristics of the study population stratified by admission body temperature.

Characteristics	Admission body temperature (°C)			
	Total	Low (< 36.6)	High (≥ 36.6)	P-value
N	6,654	2,872	3,782	
Admission body temperature (°C)	36.59 ± 0.16	36.45 ± 0.10	36.69 ± 0.11	< 0.001
Maximum body temperature (°C)	36.99 ± 0.39	36.99 ± 0.40	36.99 ± 0.37	0.711
Temperature variation (°C)	0.40 ± 0.42	0.54 ± 0.41	0.30 ± 0.39	< 0.001
Total duration of labor (min)	630.86 ± 336.80	629.60 ± 339.11	631.82 ± 335.07	0.790
Age (years)	30.08 ± 3.90	30.08 ± 3.90	30.08 ± 3.90	0.984
BMI (kg/m ²)	21.53 ± 3.14	21.64 ± 3.21	21.46 ± 3.08	0.023
Gestational age (weeks)	39.55 ± 0.93	39.54 ± 0.94	39.56 ± 0.92	0.459
White blood cell count (×10 ⁹ /L)	9.18 ± 2.28	9.19 ± 2.28	9.18 ± 2.28	0.805
Hemoglobin (g/L)	117.31 ± 11.57	117.37 ± 11.35	117.27 ± 11.73	0.745
Platelet count (×10 ⁹ /L)	215.38 ± 54.53	216.15 ± 54.11	214.80 ± 54.85	0.317
Absolute neutrophil count (×10 ⁹ /L)	6.93 ± 2.07	6.94 ± 2.07	6.92 ± 2.06	0.689
Absolute lymphocyte count (×10 ⁹ /L)	1.63 ± 0.45	1.62 ± 0.45	1.63 ± 0.45	0.489
Absolute eosinophil count (×10 ⁹ /L)	0.07 ± 0.07	0.07 ± 0.07	0.07 ± 0.07	0.883
Absolute basophil count (×10 ⁹ /L)	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.190
Absolute monocyte count (×10 ⁹ /L)	0.53 ± 0.16	0.53 ± 0.16	0.53 ± 0.16	0.796
Education level				0.330
College degree or above	5,477 (82.91%)	2,349 (82.39%)	3,128 (83.30%)	
High school or below	1,129 (17.09%)	502 (17.61%)	627 (16.70%)	
Ethnicity				0.252
Han Chinese	6,468 (97.69%)	2,794 (97.93%)	3,674 (97.51%)	
Ethnic minorities/Foreign	153 (2.31%)	59 (2.07%)	94 (2.49%)	
Use of oxytocin during labor				0.339

Characteristics	Admission body temperature (°C)			
	Total	Low (< 36.6)	High (≥ 36.6)	P-value
Yes	3,094 (48.61%)	1,314 (47.92%)	1,780 (49.13%)	0.002
No	3,271 (51.39%)	1,428 (52.08%)	1,843 (50.87%)	
Hypertensive disorders of pregnancy				0.191
No	6,529 (98.12%)	2,835 (98.71%)	3,694 (97.67%)	
Yes	125 (1.88%)	37 (1.29%)	88 (2.33%)	0.734
Gestational diabetes mellitus				
No	5,677 (85.32%)	2,469 (85.97%)	3,208 (84.82%)	0.962
Yes	977 (14.68%)	403 (14.03%)	574 (15.18%)	
Gravidity				0.962
1	3,308 (49.85%)	1,438 (50.24%)	1,870 (49.55%)	
2	1,966 (29.63%)	828 (28.93%)	1,138 (30.15%)	0.962
3	833 (12.55%)	367 (12.82%)	466 (12.35%)	
≥ 4	529 (7.97%)	229 (8.00%)	300 (7.95%)	0.962
Parity				
0	4,111 (62.01%)	1,772 (61.96%)	2,339 (62.04%)	0.962
1	2,034 (30.68%)	8,74 (30.56%)	1,160 (30.77%)	
2	426 (6.43%)	187 (6.54%)	239 (6.34%)	0.962
≥ 3	59 (0.89%)	27 (0.94%)	32 (0.85%)	

Data are presented as mean ± standard deviation or number (percentage). P-values were calculated using the t-test for continuous variables and the chi-square test for categorical variables. The low and high admission body temperature groups were defined based on the median value (36.6°C). BMI: Body mass index.

Univariate analysis of factors associated with labor duration

Table 2 presents a univariate analysis of factors associated with total duration of labor. Among temperature-related variables, a higher maximum body temperature ($\beta = 182.7$, 95% CI: 162.2 to 203.3, $P < 0.001$) and greater temperature variation ($\beta = 158.4$, 95% CI: 139.4 to 177.5, $P < 0.001$) were

significantly correlated with a prolonged labor duration, whereas admission body temperature showed no significant association ($P = 0.656$). Regarding demographic factors, increased maternal age ($\beta = -11.9$, $P < 0.001$) and higher BMI ($\beta = -4.4$, $P < 0.001$) were significantly associated with a shorter duration of labor. Compared to women with a college degree or above, those with a high school education or below had a significantly shorter labor ($\beta = -54.7$, $P < 0.001$). Ethnicity was not significantly related to labor duration ($P = 0.764$). The non-use of oxytocin during labor was strongly associated with a shorter labor duration compared to its use ($\beta = -137.2$, $P < 0.001$). While hypertensive disorders of pregnancy were not significantly associated with labor duration ($P = 0.663$), the presence of gestational diabetes mellitus was significantly correlated with a shorter labor ($\beta = -28.7$, $P = 0.014$). Both higher gravidity and parity were strongly associated with progressively shorter labor durations (all $P < 0.001$). A longer gestational age was significantly associated with a longer labor ($\beta = 49.1$, $P < 0.001$). Among the laboratory parameters, white blood cell count ($\beta = 4.9$, $P = 0.006$), hemoglobin level ($\beta = 1.5$, $P < 0.001$), and absolute neutrophil count ($\beta = 7.6$, $P < 0.001$) were positively associated with labor duration, whereas the absolute lymphocyte count showed a negative association ($\beta = -38.1$, $P < 0.001$). No significant associations were found for platelet counts, absolute eosinophil, basophil, or monocyte counts (all $P > 0.05$).

Table 2

Univariate linear regression analysis of factors associated with the total duration of labor.

Admission body temperature (°C)	Statistics	Total duration of labor (min)
	36.6 ± 0.2	-11.7 (-63.0, 39.7) 0.656
Maximum body temperature (°C)	37.0 ± 0.4	182.7 (162.2, 203.3) < 0.001
Temperature variation (°C)	0.4 ± 0.4	158.4 (139.4, 177.5) < 0.001
Age (years)	30.1 ± 3.9	-11.9 (-14.0, -9.9) < 0.001
BMI (kg/m ²)	21.5 ± 3.1	-4.4 (-7.0, -1.8) < 0.001
Education level		
College degree or above	5,477 (82.9%)	0
High school or below	1,129 (17.1%)	-54.7 (-76.2, -33.2) < 0.001
Ethnicity		
Han Chinese	6,468 (97.7%)	0
Ethnic minorities/Foreign	153 (2.3%)	-8.3 (-62.2, 45.7) 0.764
Use of oxytocin during labor		
Yes	3,094 (48.6%)	0
No	3,271 (51.4%)	-137.2 (-153.4, -121.0) < 0.001
Hypertensive disorders of pregnancy		
No	6,529 (98.1%)	0
Yes	125 (1.9%)	-13.2 (-72.9, 46.4) 0.663
Gestational diabetes mellitus		
No	5,677 (85.3%)	0
Yes	977 (14.7%)	-28.7 (-51.6, -5.8) 0.014
Gravidity		
1	3,308 (49.8%)	0
2	1,966 (29.6%)	-188.0 (-205.8, -170.3) < 0.001
3	833 (12.6%)	-247.3 (-271.4, -223.1) < 0.001
≥4	529 (8.0%)	-279.7 (-308.9, -250.6) < 0.001
Parity		

Admission body temperature (°C)	Statistics	Total duration of labor (min)
	36.6 ± 0.2	-11.7 (-63.0, 39.7) 0.656
0	4,111 (62.0%)	0
1	2,034 (30.7%)	-272.1 (-288.5, -255.7) < 0.001
2	426 (6.4%)	-307.1 (-337.9, -276.2) < 0.001
≥3	59 (0.9%)	-223.2 (-302.6, -143.8) < 0.001
Gestational age (weeks)	39.6 ± 0.9	49.1 (40.5, 57.8) < 0.001
White blood cell count (×10 ⁹ /L)	9.2 ± 2.3	4.9 (1.4, 8.5) 0.006
Hemoglobin (g/L)	117.3 ± 11.6	1.5 (0.8, 2.2) < 0.001
Platelet count (×10 ⁹ /L)	215.4 ± 54.5	-0.0 (-0.2, 0.1) 0.601
Absolute neutrophil count (×10 ⁹ /L)	6.9 ± 2.1	7.6 (3.7, 11.5) < 0.001
Absolute lymphocyte count (×10 ⁹ /L)	1.6 ± 0.4	-38.1 (-56.1, -20.1) < 0.001
Absolute eosinophil count (×10 ⁹ /L)	0.1 ± 0.1	28.9 (-92.7, 150.4) 0.642
Absolute basophil count (×10 ⁹ /L)	0.0 ± 0.0	354.4 (-245.0, 953.7) 0.247
Absolute monocyte count (×10 ⁹ /L)	0.5 ± 0.2	24.3 (-27.2, 75.8) 0.355

Data are presented as β coefficient (95% confidence interval) for continuous variables and number (percentage) for categorical variables. The total duration of labor (in minutes) was treated as the dependent variable in the univariate linear regression model. BMI: Body mass index.

Nonlinear association between temperature variation and total duration of labor

The graph illustrates the relationship between intrapartum temperature variation and total duration of labor (Fig. 2). The red solid line represents the fitted model, with blue dashed lines representing the confidence interval. Total labor duration rises with increasing temperature variation up to approximately 1.0–1.3°C, reaching a plateau near 750–800 minutes, and thereafter declines as temperature variation increases beyond this range. The confidence interval widens markedly at the extremes (especially at higher temperature variation), indicating greater uncertainty there.

The threshold effect analysis revealed a non-linear relationship between temperature variation and the total duration of labor (Table 3). In the linear model assuming a single straight-line relationship, each 0.1°C increment in temperature variation was significantly associated with a prolonged labor duration across all levels of adjustment (Model 1: $\beta = 15.4$, 95% CI: 13.5 to 17.3, $P < 0.001$; Model 2: $\beta = 10.1$, 95% CI: 8.2 to 11.9, $P < 0.001$; Model 3: $\beta = 9.9$, 95% CI: 8.1 to 11.7, $P < 0.001$). However, a segmented

regression model identified an inflection point for temperature variation at approximately 1.2°C to 1.3°C. Notably, in the fully adjusted model (Model 3), the inflection point was identified at 1.2°C. When temperature variation was below this threshold, each 0.1°C increment was strongly associated with a prolonged labor duration ($\beta = 17.4$, 95% CI: 14.6 to 20.3, $P < 0.001$). In contrast, once temperature variation exceeded 1.2°C, the association reversed, with each 0.1°C increase being significantly correlated with a shorter labor duration ($\beta = -8.0$, 95% CI: -13.6 to -2.4, $P = 0.005$). The log likelihood ratio tests confirmed that the two-piecewise linear model provided a significantly better fit than the standard linear model across all adjustment levels (all $P < 0.001$).

Table 3
Threshold effect analysis of the temperature variation and the total duration of labor

Models	Temperature variation per 0.1°C increase		
	Model 1	Model 2	Model 3
One line effect	15.4 (13.5, 17.3) < 0.001	10.1 (8.2, 11.9) < 0.001	9.9 (8.1, 11.7) < 0.001
Inflection point (K)	1.3	1.2	1.2
< K	24.7 (21.9, 27.5) < 0.001	17.4 (14.5, 20.3) < 0.001	17.4 (14.6, 20.3) < 0.001
> K	-12.8 (-19.4, -6.3) < 0.001	-7.3 (-12.9, -1.8) 0.010	-8.0 (-13.6, -2.4) 0.005
P for log likelihood ratio test	< 0.001	< 0.001	< 0.001

Data are presented as β coefficient (95% confidence interval) and P value. Model 1, adjusted for age; Model 2, adjusted for age, body mass index, education level, ethnicity, use of oxytocin during labor, hypertensive disorders of pregnancy, gestational diabetes mellitus, gravidity, parity and gestational age. Model 3, adjusted for age, body mass index, education level, ethnicity, use of oxytocin during labor, hypertensive disorders of pregnancy, gestational diabetes mellitus, gravidity, parity, gestational age, white blood cell count, hemoglobin, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count and absolute monocyte count.

Subgroup analyses

Subgroup analyses were performed to evaluate the robustness of the threshold effect across different clinical populations (Table 4 and Table 5). The inverted U-shaped association between temperature variation and total labor duration persisted in both primiparous and multiparous women, with the inflection point consistently at 1.2°C. However, while the positive association below the inflection point was significant in both groups, the negative association above the inflection point was statistically significant only in primiparous women ($P = 0.005$) but not in multiparous women ($P = 0.732$). Similarly, stratification by oxytocin use revealed a significant inverted U-shaped pattern in both subgroups, yet the

descending limb above the inflection point reached significance only among women who did not receive oxytocin ($P = 0.003$), whereas it was non-significant in those who received oxytocin ($P = 0.238$). The two-piecewise model consistently provided a superior fit compared with the linear model across all subgroups (all P for log-likelihood ratio test < 0.001). These findings indicate that the non-linear relationship between temperature variation and labor duration is generally robust.

Table 4
Threshold effect analysis of the temperature variation and the total duration of labor by parity

	Temperature variation per 0.1°C increase	
	β (95% CI)	P-value
Primiparous women		
One line effect	9.3 (7.0, 11.5)	< 0.001
Inflection point (K)	1.2	
$< K$	17.5 (13.9, 21.1)	< 0.001
$> K$	-10.0 (-17.0, -3.0)	0.005
P for log likelihood ratio test		< 0.001
Multiparous women		
One line effect	11.3 (8.2, 14.4)	< 0.001
Inflection point (K)	1.2	
$< K$	16.6 (11.8, 21.4)	< 0.001
$> K$	-1.6 (-11.1, 7.8)	0.732
P for log likelihood ratio test		< 0.001

Data are presented as β coefficient (95% confidence interval) and P value. Adjusted for age, body mass index, education level, ethnicity, use of oxytocin during labor, hypertensive disorders of pregnancy, gestational diabetes mellitus, gestational age, white blood cell count, hemoglobin, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count and absolute monocyte count.

Table 5
Threshold effect analysis of the temperature variation and the total duration of labor by oxytocin use

	Temperature variation per 0.1°C increase	
	β (95% CI)	P-value
Oxytocin use		
One line effect	11.0 (8.4, 13.7)	< 0.001
Inflection point (K)	1.2	
< K	17.8 (13.5, 22.0)	< 0.001
> K	-5.0 (-13.3, 3.3)	0.238
P for log likelihood ratio test		< 0.001
No oxytocin use		
One line effect	8.0 (5.5, 10.4)	<0.001
Inflection point (K)	1.2	
< K	16.2 (12.4, 20.1)	< 0.001
> K	-11.4 (-18.9, -4.0)	0.003
P for log likelihood ratio test		< 0.001

Data are presented as β coefficient (95% confidence interval) and P value. Adjusted for age, body mass index, education level, ethnicity, hypertensive disorders of pregnancy, gestational diabetes mellitus, gravidity, parity, gestational age, white blood cell count, hemoglobin, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count and absolute monocyte count.

Discussion

In this large, cross-sectional study of 6,654 parturients receiving epidural analgesia, we identified a robust non-linear, inverted U-shaped relationship between intrapartum temperature variation and the total duration of labor. The key finding is a threshold effect at a temperature variation of approximately 1.2°C. Below this threshold, increasing temperature variation was significantly associated with prolonged labor. Conversely, above this threshold, further increases in temperature variation were significantly correlated with a shorter labor duration. This non-linear pattern persisted across multiple adjustment levels and was generally consistent in subgroup analyses.

Prior investigations predominantly defined intrapartum fever using categorical thresholds (e.g., fever vs no fever) and reported associations between fever and adverse obstetric outcomes, including prolonged

labor, often treating temperature trajectories as linear predictors of labor duration or outcomes(17–19). This study treats intrapartum temperature variation as a continuous variable and employs nonlinear modelling to characterize its relationship with labor duration. This aligns with emerging evidence which reported the relationship between fever characteristics (e.g., peak temperature, duration) and neonatal morbidity may not be strictly linear (20, 21).

Our findings reveal a positive correlation between mild temperature variation and prolonged labor. This is consistent with previous research on intrapartum thermoregulation, which has demonstrated that epidural-related maternal fever is frequently associated with prolonged labor(22). The initial positive association between temperature variation and labor duration below the inflection point is biologically plausible. The underlying mechanisms are likely multifaceted. First, epidural analgesia may prolong labor by directly altering uterine contractility and labor coordination through sympathetic blockade, which can reduce the frequency and synchronization of contractions and extend the first stage of labor(15, 22–24). Concurrently, epidural-related fever (ERF) is widely regarded as arising from a non-infectious inflammatory mechanism, wherein analgesic medications may trigger aseptic inflammation and the release of cytokines such as IL-6, which not only act on central thermoregulatory pathways to elevate body temperature but may also influence myometrial contractility(25, 26).

The reversal of the association beyond the 1.2°C threshold presents an intriguing finding that warrants careful interpretation. Several mechanisms may explain this phenomenon. From a physiological standpoint, shorter labor duration may coincide with accelerated metabolic turnover and hemodynamic shifts, leading to greater temperature variability in some women(27, 28). This effect could be further amplified by the intense uterine activity characteristic of a rapid labor course, which itself is a major source of metabolic heat(27). Beyond physiology, clinical intervention bias represents an important consideration. In contemporary obstetric practice, significant maternal temperature elevation (particularly approaching or exceeding 38.0°C) typically prompts accelerated management to reduce risks of chorioamnionitis and neonatal sepsis. Clinicians may increase oxytocin infusion rates, perform artificial rupture of membranes, or prepare for instrumental delivery—interventions that independently shorten labor duration(29–31). Although we adjusted for oxytocin use in our multivariable models, we lacked detailed timing information regarding when such interventions were initiated relative to temperature measurements. This limitation may have resulted in residual confounding that could not be fully addressed.

The persistence of the inverted U-shaped pattern across parity and oxytocin use strata supports the generalizability of our principal finding. However, the negative association above the inflection point reached statistical significance only in primiparous women and those not receiving oxytocin. The lack of significance in multiparous women may reflect reduced statistical power due to shorter baseline labor durations and potentially smaller effect sizes, rather than a true biological difference. Similarly, oxytocin use represents a powerful intervention that could obscure more subtle relationships between temperature and labor progression. Alternatively, oxytocin administration may itself be a marker of underlying labor complexity, which could entail distinct thermodynamic profiles(32–34).

Our findings highlight the analytical and clinical advantages of treating temperature as a continuous variable in the intrapartum setting. A binary fever/non-fever classification fails to capture the complex, nonlinear dynamics between temperature change and labor progression identified in this study. Consequently, the routine practice of episodic fever screening may be insufficient for adequate risk assessment. Our findings advocate for continuous monitoring of temperature variation throughout labor, as this approach provides richer prognostic information and may allow clinicians to identify at-risk patients earlier, thereby facilitating more personalized and timely obstetric care.

Several limitations should be acknowledged. First, the cross-sectional design precludes causal inferences. Second, residual confounding may persist from unmeasured factors, including the precise timing of clinical interventions relative to temperature measurements, detailed infectious workup results, and indicators of maternal nutritional status. Third, the single-center design may limit generalizability to populations with different demographic characteristics, obstetric practices, or epidural analgesia protocols; thus, validation in other settings is warranted.

Prospective cohort studies with serial measurements of temperature, inflammatory biomarkers, and uterine contractility patterns are needed to elucidate the mechanisms underlying the observed associations. Studies examining neonatal outcomes in relation to maternal temperature patterns would further clarify the clinical significance of our findings. Additionally, multicenter studies across diverse populations would enhance generalizability and potentially identify effect modification by practice patterns or population characteristics.

Conclusions

This study demonstrates an inverted U-shaped relationship between intrapartum temperature variation and total labor duration in women receiving epidural analgesia, with an inflection point at approximately 1.2°C. Below this threshold, temperature elevation is associated with prolonged labor; above it, further elevation is associated with shorter labor duration. These findings suggest that temperature change is a dynamic marker of labor progression and highlight the need for individualized assessment of parturients with epidural-related temperature changes.

Declarations

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics statement

The studies involving humans were approved by the Ethics Committee for Scientific Research Projects of Maternity&Child Healthcare Hospital of Longgang District, Shenzhen City. The studies were conducted in

accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements. Written informed consent was not obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article because in accordance with the Declaration of Helsinki and the relevant STROBE guidelines, this study was approved by the Ethics Committee for Scientific Research Projects of Maternity&Child Healthcare Hospital of Longgang District, Shenzhen City (LGFYKYXMLL-2025-10). Anonymous data analysis was conducted, and informed consent was not required.

Authors' contributions

Zhuangbo Wu: Data curation, Formal Analysis, Methodology, Software, Visualization, Writing – original draft. Hongtian Yu: Data curation, Formal Analysis, Methodology, Writing – original draft. Weiqi Ke: Data curation, Writing – original draft. Jingmei Zhou: Data curation, Writing – original draft. Jingxin Shi: Data curation, Writing – original draft. Yuqing Lai: Data curation, Writing – original draft. Wenbo Chen: Data curation, Writing – original draft. Zhengqin Wu: Data curation, Writing – original draft, Yang Zhao: Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Figures

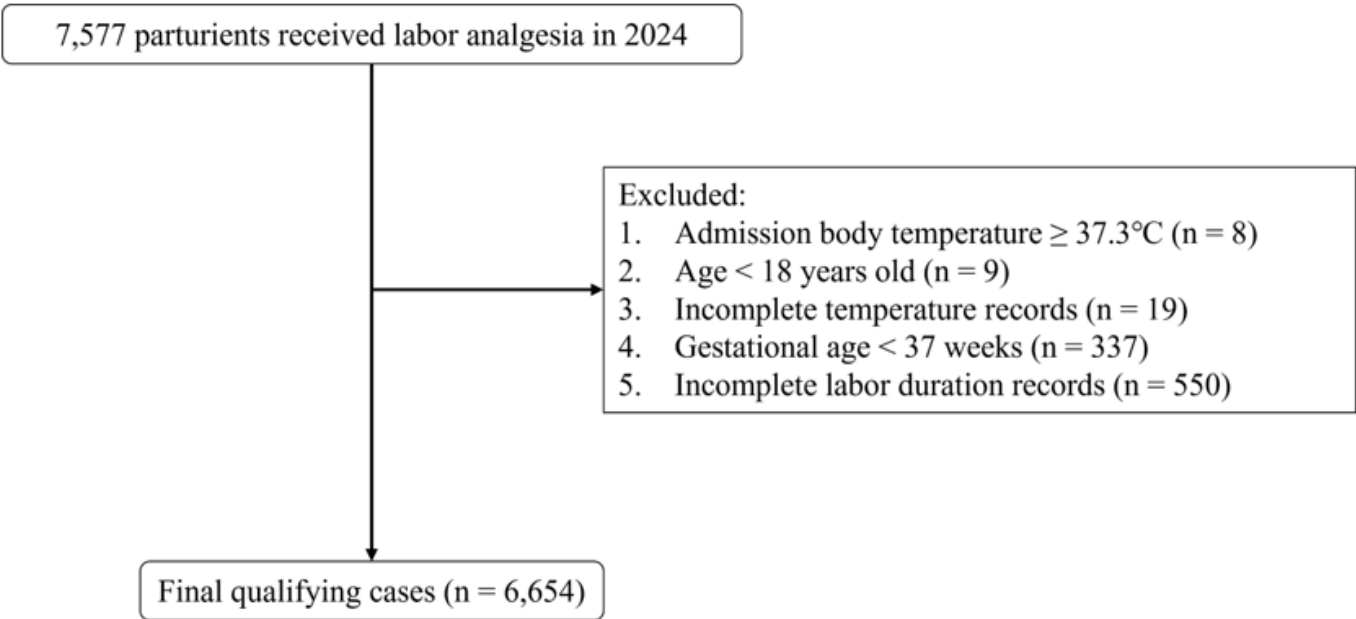


Figure 1

Flow chart of study population.

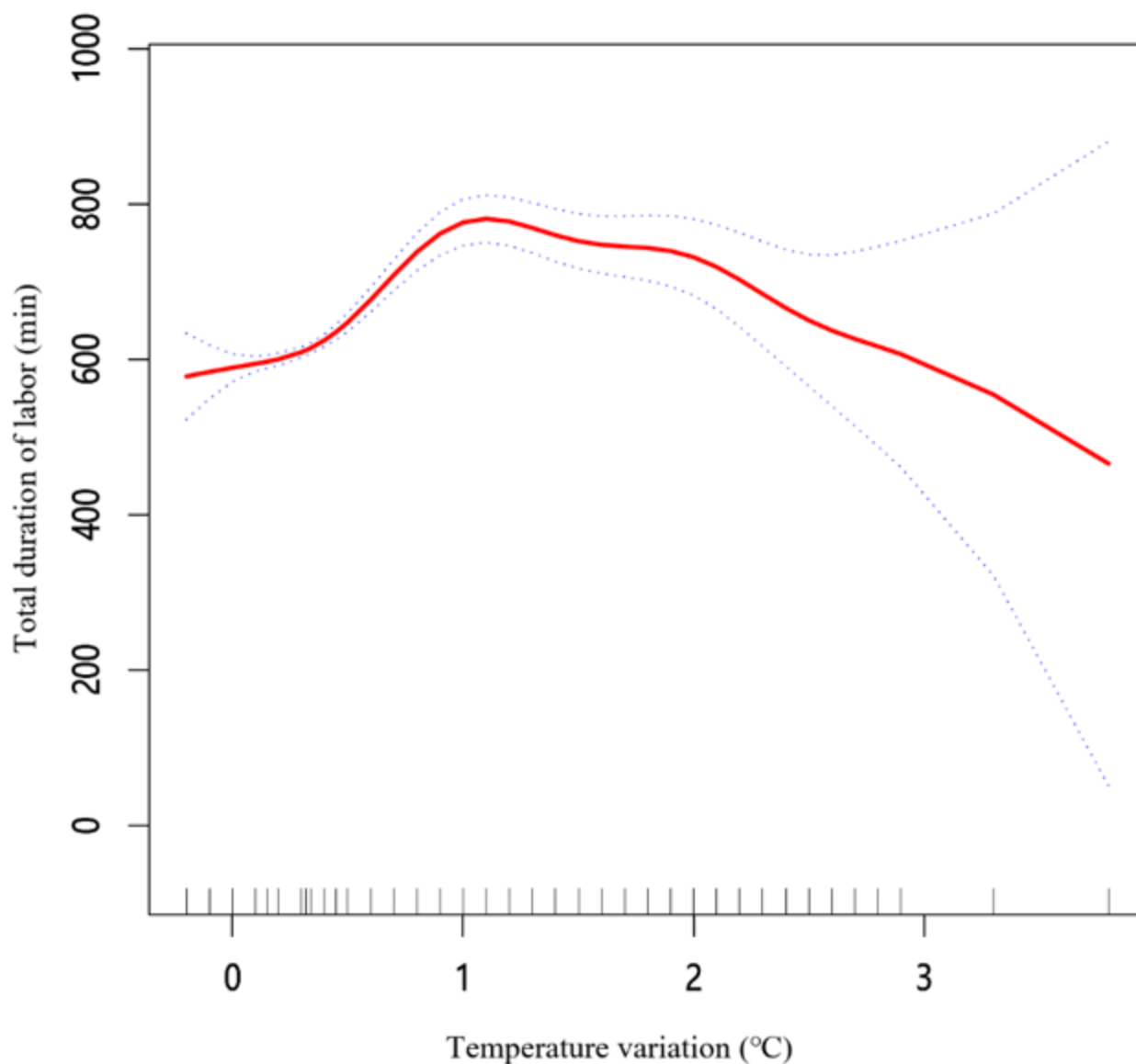


Figure 2

Associations between temperature variation and total duration of labor. The solid line and dashed line represent the estimated values and their corresponding 95% confidence intervals. Adjustment factors included age, body mass index, education level, ethnicity, use of oxytocin during labor, hypertensive disorders of pregnancy, gestational diabetes mellitus, gravidity, parity, gestational age, white blood cell count, hemoglobin, platelet count, absolute neutrophil count, absolute lymphocyte count, absolute eosinophil count, absolute basophil count and absolute monocyte count.