Russian Journal of Anesthesiology and Reanimatology
2026, No. 2, pp. 93–107
https://doi.org/10.17116/anaesthesiology202602193

Inadvertent hypothermia in obstetric patients: prevention and treatment (a scoping review)

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ABSTRACT

Background. A few reports on prevention and correction of inadvertent hypothermia in parturient and postpartum women, the need to clarify definitions of this condition and heterogeneous evidence on effectiveness of methods for its correction inspired this review.
Objective. To expand data on prevention and correction of inadvertent hypothermia in obstetrics.
Material and methods. The review was conducted in accordance with the PRISMA-ScR guidelines. Five databases (from January 1990 to May 2025) were searched for publications on active and passive warming methods for parturient and postpartum women. Eligibility criteria (PCC): (P) — population: women in labor and postpartum women regardless of urgency and method of delivery, (C) — concept: inadvertent hypothermia, warming methods, (C) — context: correction of hypothermia in context of blood loss, postpartum hemorrhage, coagulopathy. Types of sources: primary studies, meta-analyses, ScR, guidelines. Source management: Mendeley Desktop, review management: Rayyan. An iterative EXCEL form was developed for data extraction. ScR protocol registered: INPLASY202580010.
Results. The ScR included 40 publications from 19 countries. The term "inadvertent perioperative hypothermia" was the most common (unintentional, unintended, or accidental hypothermia). Most studies included healthy women who had undergone cesarean section under regional anesthesia. The most common methods for active warming were warming of infusion solutions (75%), convective blankets (37%), and combinations of these methods (45%). Preoperative active warming is indicated in 58% of sources. The incidence of postpartum hemorrhage was recorded in four studies, but none assessed the incidence of coagulopathic bleeding.
Conclusion. Multimodal strategy of active warming initiated before delivery and continued in intraoperative and postoperative period is optimal. The effect of hypothermia on blood loss in context of postpartum hemorrhage remains virtually unexplored. Further research may allow hypothermia to be considered as a factor aggravating obstetric blood loss.

Keywords: *maternal hypothermia, perioperative hypothermia, cesarean section, spontaneous delivery, scoping review.*

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TO CITE THIS ARTICLE:
Barkovskaya NA, Shifman EM, Protsenko DN, Lebedinskii KM, Katkova NYu. Inadvertent hypothermia in obstetric patients: prevention and treatment (a scoping review). *Russian Journal of Anesthesiology and Reanimatology*. 2026;2:93–107. (In Russ.).
https://doi.org/10.17116/anaesthesiology202602193

Introduction

Inadvertent perioperative hypothermia (IPH) is an accidental or unintentional core body temperature decrease below 36.0 °C. This is a complication and can lead to cold injury [1]. In 2009, Yokoyama K. et al. [2] demonstrated hypothermia in 30—60% of women undergoing cesarean section (CS) under regional anesthesia. IPH can lead to poor outcomes of CS and labor, including abnormal blood loss, tremble, infectious complications, delayed recovery, and cardiovascular complications [3].

According to network meta-analysis, the most effective methods for preventing and correcting maternal hypothermia during CS were conductive mattress (OR=0.27, 95% CI 0.08—0.93) and its combination with warming of infusion solutions (OR=0.45, 95% CI 0.27—0.75) [4]. According to the authors, active warming will improve the quality of CS through correction of hypothermia.

However, further research should focus on volume and rate of blood loss, the need for blood transfusions, shock or thrombotic disorders. The effect of hypothermia on blood loss in context of postpartum hemorrhage (PPH) remains virtually unstudied.

We chose ScR methodology (scoping review) due to small number of studies, the need to clarify definitions of unintentional hypothermia, heterogeneous evidence on effectiveness of methods for correcting IPH in obstetrics.

The purpose of the study was to expand our understanding of methods for preventing and correcting IPH in obstetrics. We described, compared and summarized literature data, identified gaps in knowledge and justified directions for future clinical research.

Review questions:

1. What methodologies are used in studies of prevention and correction of IPH in obstetric patients? What outcomes are reported? How are these outcomes measured?
2. Are there differences in definitions of IPH in surgical practice and obstetrics?
3. What methods for correcting hypothermia in women undergoing abdominal or vaginal delivery, as well as in postpartum period are covered in the literature?
4. Additional questions:
   a. What specific modes of delivery (vaginal delivery, elective, urgent, or emergency CS), anesthesia methods and predicted blood loss volume are addressed by known methods for preventing and correcting hypothermia?
   b. What factors contribute to hypothermia in obstetric patients?
   c. What are negative consequences of IPH in obstetrics, including patients with PPH?
5. What are the knowledge gaps, taking into account types of evidence synthesis?

Material and methods

The review was conducted according to the JBI (The Joanna Briggs Institute) methodology for scoping reviews and PRISMA-ScR extension [5, 6]. A systematic review with ScR methodology is based on systematic searching for studies of various designs on certain issue to identify key concepts, theories, sources of evidence, gaps in knowledge and research [7].

The ScR protocol is registered on the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY) under the number INPLASY202580010 (https://doi.org/10.37766/inplasy2025.8.0010). The PRISMA-ScR checklist is presented in supplements, **Tables S1** and **S2** (hereinafter supplements **Tables S1—S5**, **Fig. S1, S2**, QR code at the end of the article).

Ethical approval was unnecessary, as previously published data were analyzed.

Searching strategy

We screened the PubMed, EBSCO, and Mendeley databases for the period from 1990 to March 2025 using the following queries: active warming; hypothermia; epidural anesthesia; spinal anesthesia; obstetric anesthesia; anesthetic recovery; anaesthesia; epidural; spinal; obstetric*; anaesthe*; postanaesthe*; neuraxial; caesarean section; caesarean*; cesarean, c-section; abdominal delivery; abdominal deliveries; delivery; postnatal care; postpartum; scoping reviews; systematic reviews. Logical operators AND and OR were applied. The following keywords were used in Russian-language databases (Google Scholar and eLIBRARY.RU): гипотермия; активное согревание, кесарево сечение; роды; спинальная анестезия; эпидуральная анестезия; периоперационный период. There were no restrictions on the language of reports. Searching was updated in May 2025, and no additional sources were identified.

Eligibility criteria and study selection

Publications were included in ScR according to PCC eligibility criteria **(Table 1)** [8].

Exclusion criteria: non-obstetric population, unpublished manuscripts, letters to the editor, conference abstracts, unavailable full-text article.

Study designs: primary studies (randomized controlled trials (RCTs), quasi-RCTs, case-control studies, cohort studies), systematic reviews, meta-analyses, ScRs, guidelines.

References were managed in Mendeley Desktop (Elsevier, v1.19.8, 2020). After removing duplicates, we imported publications into Rayyan review management system [9]. Baseline screening of titles and abstracts was performed by two authors. Full texts were assessed for inclusion criteria; disagreements were resolved through discussion with a third author. We analyzed references of relevant studies.

An iterative Excel form was developed for data extraction. This form included the first author's name, year, country, study design, methodology, objective, participants, sample size, concept, definition of hypothermia, intervention, context, results and key findings. Qualitative evidence synthesis is presented in tables, map of rewarming methods, graphs and text.

Results

We identified 258 articles. After removing duplicates, we screened titles and abstracts of 219 articles, and 140 were excluded as irrelevant. Then, 2 authors screened full-text articles regarding eligibility. Among 79 full-text articles, 39 were excluded for certain reasons **(Table S3)**. A total of 40 publications were included in qualitative synthesis. Importantly, 11 RCTs in ScR were also included in one or more meta-analyses. However, meta-analyses do not reflect all information relevant to the questions. Thus, we included 40 publications in ScR to ensure complete data **(Fig. 1)**.

Characteristics of studies

Among all studies, one-third (33%) were published within the last 5 years **(Fig. 2)**. Eight study design categories were identified in accordance with the JBI classification **(Table 2)** [4, 10—47].

Table 1. **Eligibility criteria (PCC)**

PCC	Inclusion criteria
Population	Women in labor and those in postpartum period regardless of delivery method and urgency (elective, urgent, emergency CS [8], spontaneous and induced labor)
Concept	Inadvertent hypothermia, rewarming methods (definitions, methodological approaches, study designs, interventions)
Context	Correction of hypothermia in context of blood loss, PPH, coagulopathy

More than half of studies were RCTs. The review also enrolled four meta-analyses including 1 network review. The journals covered the following areas: anesthesiology and intensive care — 18 (45%), anesthesia in obstetrics — 8 (20%), obstetrics and gynecology — 8 (20%), surgery — 2 (5%), nursing — 1 (2.5%), medicine (miscellaneous) — 3 (7.5%). Fourteen RCTs used a two-arm design [2, 13—16, 19, 21—23, 25, 28—30, 32], 6 RCTs included three groups of participants [17, 18, 20, 26, 27, 31], and one RCT included four parallel groups of women in labor [24]. In a prospective observational study, Masuku N. et al. [35] developed a model for predicting hypothermia during CS under spinal anesthesia (SA). Zhang R. et al. [39] performed a multivariate regression analysis of risk factors of hypothermia and methods of rewarming patients during emergency CS under SA. Sample sizes ranged from 1 to 1241 participants. Only 2 studies had multiple-center design [22, 41]. The studies were conducted in 19 countries; their geography is presented in **Table 3** [2, 4, 10—47], **Fig. S1** (QR code). Language of publications: English — 39, Portuguese — 1.

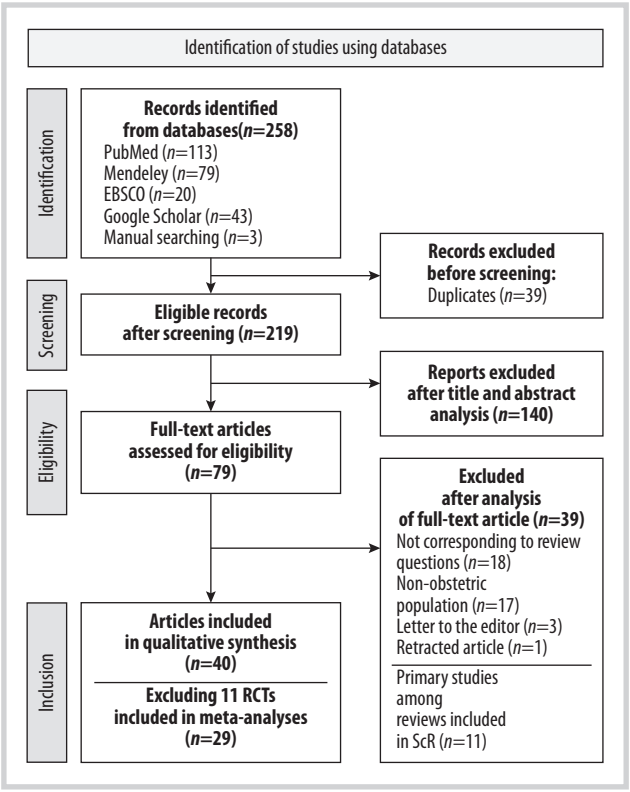

Fig. 1. **PRISMA-ScR (2018) flowchart.**

Operating theater and post-anesthesia care unit (PACU) air temperature was recorded in more than half of studies, but only one examined the effect of temperature ⩾23 °C on the incidence of maternal IPH [15].

Terminology

Definitions of hypothermia were provided in 27 studies. The definition presented in the NICE (2016) guideline was the most common [48] **(Table 4)** [4, 11—14, 16, 17, 19, 22, 24, 26, 28, 29, 31—35, 37, 39—46, 48—50] **(Fig. S2, QR code)**.

The review included only foreign sources. The term "inadvertent perioperative hypothermia" was the moist common. The adjectives "unintended" and "accidental" carry the same meaning. Fallis W.M. et al. [22] used the term "mild intraoperative hypothermia" emphasizing degree of hypothermia and its limitation to intraoperative period. In 2 studies, the authors examined cases of clinically significant hypothermia (core temperature decrease by more than 1 °C compared to baseline) after SA [35, 37].

In clinical practice, it is customary to focus on central body temperature, the so-called core temperature (central nervous system, thoracic and abdominal organs). This temperature is 2—4 °C higher than temperature of extremities and normally ranges from 36.0 °C to 37.5 °C. Sud S. et al. [43] present definition of hypothermia adopted in trauma patients: CBT<36 °C with further gradation into mild (<36 °C, ⩾34 °C), moderate (<34 °C, ⩾32 °C) and severe (<32 °C) hypothermia. In 70% of publications, threshold CBT<36 °C was established for IPH from the NICE guidelines (2016) [48] and extrapolated to obstetric population **(Table 5)**.

Five publications presented other temperature thresholds:<36.5 °C in 3 studies [15, 22, 31],<35.5 °C in 1 study [21] and 1 case report of hypothermia (<35 °C) in a patient after vaginal delivery [47]. Thus, most studies recognized CBT<36 °C as hypothermia requiring active intervention.

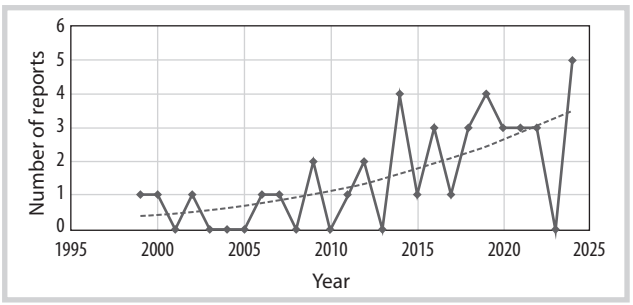

Fig. 2. **Number of publications included in ScR (by year of research).**

Table 2. **Types of publications included in ScR**

Study design	Year	Number of reports, *n* (%)	Reference
Network meta-analysis of RCTs	2019	1 (2.5)	[4]
Systematic review with meta-analysis of RCTs	2014, 2015, 2022	3 (7.5)	[10—12]
RCTs	2000—2024	21 (52.5)	[2, 13—32]
Quasi-experimental study	2014	1 (2.5)	[33]
Prospective observational study	1999, 2018, 2020, 2024	5 (12.5)	[34—38]
Retrospective observational study	2019, 2020, 2021, 2022, 2024	5 (12.5)	[39—43]
Narrative review	2012, 2018	3 (7.5)	[44—46]
Case report	2022	1 (2.5)	[47]

Table 3. **Number of studies included in ScR by countries**

No.	Country	Number of studies	Reference
1	USA	9	Cobb, 2016 [14]; Duryea, 2016 [15]; Paris, 2014 [17]; Butwick, 2007 [21]; Hoefnagel, 2020 [42]; Allen, 2018 [44]; Cohen, 2018 [45]; Carpenter, 2012 [46]; Weishaar, 2022 [47]
2	United Kingdom	5	Chebbout, 2017 [31]; Chakladar, 2014 [16]; Woolnough, 2009 [20]; Sultan, 2015 [11]; Thorburn, 2021 [41]
3	China	4	Yang 2021 [27]; Ni, 2020 [28]; Zhuo 2022 [10]; Zhang, 2024 [39]
4	India	3	Goyal, 2011 [19]; Sud, 2019 [43]; Meghana, 2020 [36]
5	Germany	2	Horn, 2002 [23]; Marin, 2022 [40]
6	Korea	2	Jun, 2019 [29]; Chung, 2012 [18]
7	Turkey	2	Akdag Topal, 2024 [24]; Cantürk, 2019 [30]
8	Republic of South Africa	2	Masuku, 2024 [35]; Toit, 2018 [37]
9	Australia	1	Munday, 2014 [12]
10	Austria	1	Panzer, 1999 [38]
11	Brazil	1	Bernardis, 2016 [32]
12	Denmark	1	Jørgensen, 2000 [25]
13	Israel	1	Haim, 2024 [13]
14	Iran	1	Oshvandi, 2014 [33]
15	Italy	1	Cotoia, 2021 [26]
16	Canada	1	Fallis, 2006 [22]
17	Norway	1	Brodshaug, 2024 [34]
18	Taiwan	1	Chen, 2019 [4]
19	Japan	1	Yokoyama, 2009 [2]

Table 4. **Definitions of inadvertent hypothermia in various publications**

Source of definition	Definition	Number of reports, *n*, (%)	References
NICE, 2008 [48]	Inadvertent perioperative hypothermia (IPH) — a patient's core body temperature (CBT)<36 °C associated with surgical procedure	7 (26)	[11, 12, 14, 16, 19, 31, 33]
NICE, 2016 [48]	Inadvertent perioperative hypothermia (IPH) — CBT<36 °C in surgical patients	13 (48)	[4, 13, 24, 28, 29, 32, 35, 39—44]
NICE, 2016 [48]	Unintended perioperative hypothermia (UPH) — CBT<36.0 °C	1 (3.7)	[34]
NICE, 2016 [48]	Accidental hypothermia — CBT<36.0 °C	1 (3.7)	[45]
SIAARTI Best Clinical Practice [49]	Inadvertent perioperative hypothermia (IPH) — unintentional decrease of CBT<36 °C	1 (3.7)	[26]
Clinical practice guideline: Preventing IPH [50]	Perioperative hypothermia — CBT<36 °C	1 (3.7)	[37]
Author's definition	Mild intraoperative hypothermia — CBT 35—36.5 °C)	1 (3.7)	[22]
Author's definition	Maternal hypothermia after planned cesarean (MHAPC)	1 (3.7)	[17]
Author's definition	Perioperative hypothermia — definition is not strictly agreed upon, but is most often considered to be CBT<36 °C; mild hypothermia is defined as CBT 34—36 °C	1 (3.7)	[46]

Table 5. **Thresholds of inadvertent hypothermia**

No.	Temperature, °C	Share	Number	%
1	35		1	3
2	35.5		1	3
3	36		28	70
4	36.5		3	8
5	N/R		7	18

Note. N/R — not reported.

Devices for core temperature measurement

Methods, devices, and location of temperature measurement varied **(Table S4, QR code)**. A third of the studies used an infrared tympanic thermometer. SpotOn technology ("zero heat flux" with a sensor on lateral forehead in projection of temporal artery) was used in 17% of studies. Toit L. et al. [37] measured core temperature using ingestible intestinal telemetry sensor. Real-time data analysis with further monitoring in PACU allowed clinicians to focus on a critical aspect: the need for active rewarming of women in labor.

Methods for rewarming patients during abdominal and vaginal deliveries

Active rewarming was most often performed by warming infusion solutions (75%), convective blankets with airflow to warm the upper or lower body, full-size blankets (37%), and combination of these methods (45%) **(Table 6)** [2, 4, 10—47].

There was significant variability in methods of warming infusion solutions and temperature ranges (37—41 °C). In 45% of studies, warming was performed using various models of heaters in infusion line. Heating cabinet (33%) and water bath (13%) were less common.

Convective blankets were used to warm the lower body alone in 7 studies, while 9 studies indicated warming of the upper body. Full-size blankets, including those with surgical access, were used in 5 studies **(Table 6)**. Slightly less than half of the studies indicated combination of convective blankets and warming of infusion solutions. Convective thermal gowns were less common for preoperative warming. Temperature range for convective methods was 38—43 °C.

Conductive mattress alone was used in two studies, in combination with other active warming devices — in 5 trials. Only one study described warming of respiratory gas during mechanical ventilation [45]. CS under general anesthesia was performed in 8 studies.

Passive warming methods, in addition to general care (regular blankets), include reflective blankets and air temperature in the operating room and PACU ⩾23 °C. There is a poorly studied method of preoperative oral carbohydrate loading. In obstetric patients, it was described in only one report [27]. Oral carbohydrate intake 2 hours before CS under combined spinal-epidural anesthesia maintains intraoperative body temperature.

Timing of warming largely determines its clinical effectiveness. Preoperative active warming was used in 58% of studies (alone and in combination with intraoperative and postoperative warming) **(Fig. 3)**.

Warming methods for women undergoing vaginal birth are almost nonexistent in the literature. The majority of reports examine abdominal delivery. More than half of these included patients after elective CS **(Table 7)**.

According to the NICE guidelines (2016), active rewarming should be initiated to maintain preoperative temperature >36 °C, except in emergency surgeries [48]. Only 8% of studies in our ScR included urgent and emergency procedures [39, 41, 45]. In 10% of reports, CS of any urgency was included in analysis [10, 12, 15, 46]. In 8% of studies, patients underwent either elective or emergency CS [35, 40, 44]. This inevitably biased final results due to different urgency of procedures and preparation time.

ASA classes

ASA classes did not exceed II in most studies **(Fig. 4)**. Only 4 studies [13, 15, 16, 41] excluded patients with high

Table 6. **Map of patient warming methods in various studies included in ScR**

No.	Study	Warming of infusion solutions	Convective blanket (u, l, f)	Reflective blanket	Pre-warmed blanket	Conductive mattress	[Convective blanket (u, l, f)+warming of infusion solutions]	[Conductive mattress+warming of infusion solutions]	[Thermal gown+warming of infusion solutions]	[Thermal gown+convective blanket (u, l, f)+warming of infusion solutions]	[Convective blanket (u, l, f)+pre-warmed blanket]	[Convective blanket (u, l, f)+warming of infusion solutions+ pre-warmed blanket]	[Pre-warmed blanket+warming of infusion solutions]	Temperature in the operating room ⩾23 °C	Preoperative oral carbohydrate load	Passive rewarming during labor	Warming of breathing mixture (mechanical ventilation)
1	Haim, 2024 [13]	√	—	—	—	—	√l	—	—	—	—	—	—	—	—	—	—
2	Akdag Topal, 2024 [24]	—	—	—	—	—	√u, l, f	—	—	—	—	—	—	—	—	—	—
3	Cotoia, 2021 [26]	√	√u	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	Yang, 2021 [27]	—	—	—	—	—	—	—	—	—	—	—	—	—	√	—	—
5	Ni, 2020 [28]	√	√u	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	Jun, 2019 [29]		—	—	—	—	√f	—	—	—	—	—	—	—	—	—	—
7	Cantürk, 2019 [30]	√	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	Chebbout, 2017 [31]	√	—	—	—	—	√f	√	—	—	—	—	—	—	—	—	—
9	Bernardis, 2016 [32]	√	—	—	—	—	—	—	—	√u	—	—	—	—	—	—	—
10	Cobb, 2016 [14]	√	√f*	—	—	—	√l	—	—	—	—	—	—	—	—	—	—
11	Duryea, 2016 [15]	—	—	—	—	—	—	—	—	√u	—	—	√	√	—	—	—

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Table 6. **Map of patient warming methods in various studies included in ScR. (Ending)**

No.	Study	Warming of infusion solutions	Convective blanket (u, l, f)	Reflective blanket	Pre-warmed blanket	Conductive mattress	[Convective blanket (u, l, f)+warming of infusion solutions]	[Conductive mattress+warming of infusion solutions]	[Thermal gown+warming of infusion solutions]	[Thermal gown+convective blanket (u, l, f)+warming of infusion solutions]	[Convective blanket (u, l, f)+pre-warmed blanket]	[Convective blanket (u, l, f)+warming of infusion solutions+ pre-warmed blanket]	[Pre-warmed blanket+warming of infusion solutions]	Temperature in the operating room ⩾23 °C	Preoperative oral carbohydrate load	Passive rewarming during labor	Warming of breathing mixture (mechanical ventilation)
12	Chakladar, 2014 [16]	✓	—	—	—	—	—	✓	—	—	—	—	—	—	—	—	—
13	Paris, 2014 [17]	✓	—	—	✓	✓	—	—	—	—	—	—	—	—	—	—	—
14	Chung, 2012 [18]	✓	✓u	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	Goyal, 2011 [19]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	Woolnough, 2009 [20]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	Yokoyama, 2009 [2]	✓	—	✓	—	—	—	—	—	—	—	—	—	—	—	—	—
18	Butwick, 2007 [21]		✓l	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	Fallis, 2006 [22]	✓	—	—	—	—	✓u	—	—	—	—	—	—	—	—	—	—
20	Horn, 2002 [23]	✓	—	—	—	—	✓f, u	—	—	—	—	—	—	—	—	—	—
21	Jørgensen, 2000 [25]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	Oshvandi, 2014 [33]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23	Zhuo, 2022 [10]	✓	✓l	—	—	—	✓f, u	✓	—	✓	—	—	—	—	—	—	—
24	Sultan, 2015 [11]	✓	✓u	✓	✓	—	✓u		—	—	—	—	✓	—	—	—	—
25	Munday, 2014 [12]	✓	✓u	✓	✓	—	✓u	✓	—	—	—	—	—	—	—	—	—
26	Chen, 2019 [4]	✓	✓		✓	✓	✓u, l, f	✓	✓	✓	✓	✓	✓	—	—	—	—
27	Zhang, 2024 [39]	✓	—	✓	—	—	✓u, l, f	—	—	—	—	—	—	✓	—	—	—
28	Marin, 2022 [40]		✓f	—	—	—	—	—	—	—	—	—	—		—	—	—
29	Thorburn, 2021 [41]	✓	✓u, l	—	—	—	—	—	—	—	—	—	—		—	—	—
30	Hoefnagel, 2020 [42]	—	—	—	—	—	—	—	—	✓l	—	—	✓		—	—	—
31	Sud, 2019 [43]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	Brodshaug, 2024 [34]	✓	—	—	✓	—	—	—	—	—	—	—	—	—	—	—	—
33	Masuku, 2024 [35]	✓	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
34	Meghana, 2020 [36]	—	✓l	—	—	—	✓l	—	—	—	—	—	—	—	—	—	—
35	Toit, 2018 [37]	✓	—	—	—	—	✓u, l, f	—	—	—	—	—	—	—	—	—	—
36	Panzer, 1999 [38]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	✓	N/A
37	Allen, 2018 [44]	✓	✓u, l, f	—	—	—	✓u, l, f	—	—	—	—	—	—	—	—	—	—
38	Cohen, 2018 [45]	✓	✓u, l, f	—	—	—	✓u, l, f	—	—	—	—	—	—	✓	—	—	✓
39	Carpenter, 2012 [46]	✓	✓u, l, f	—	—	—	✓u, l, f	—	—	—	—	—	—	—	—	—	—
40	Weishaar, 2022 [47]	—	—	—	—	—	✓f	—	—	—	—	—	—	—	—	✓	N/A

Note. convective blanket options: l — for the lower body; u — for the upper body; f — full-size including surgical access; N/A — not applicable. * — only in postoperative care unit. Active warming methods are shown in regular font, passive warming methods are shown in italics. In some studies [Hoefnagel, 2020, Chebbout, 2017 Bernardis, 2016, Chakladar, 2014, Fallis, 2006, Horn, 2002], warming of infusion solutions was considered as a passive warming method.

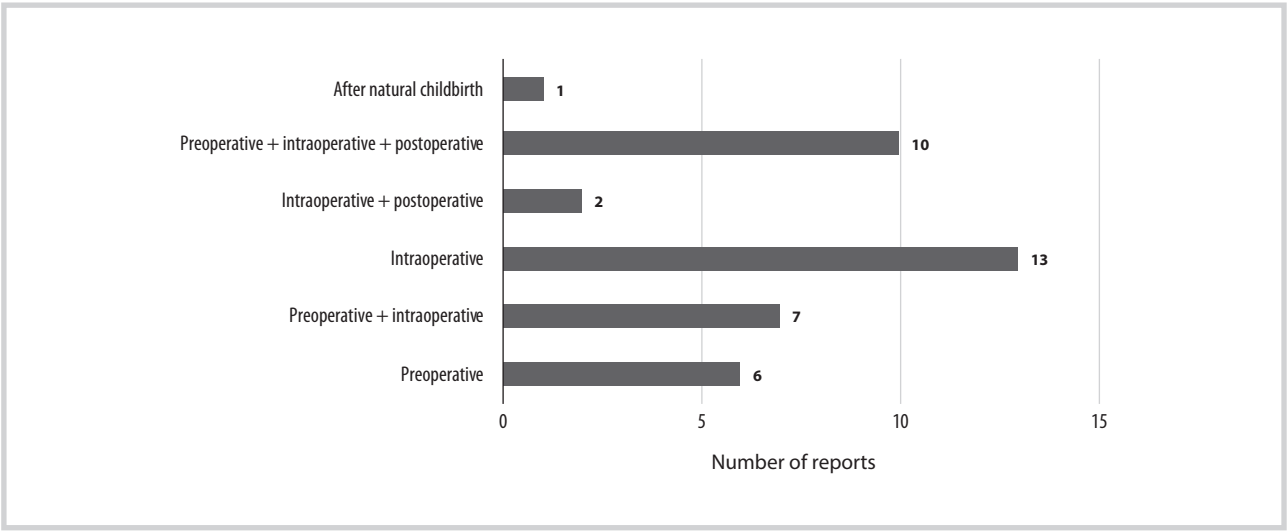

Fig. 3. **Modes of active warming interventions.**

Table 7. **Delivery methods in various studies**

No.	Method of delivery	Share	Number	%
1	Urgent CS Emergency CS		1	3
2	Elective CS		28	70
3	Elective CS Urgent CS Emergency CS		4	10
4	Elective CS Emergency CS		3	8
5	Natural childbirth		2	5
6	Emergency CS		2	5

ASA classes that is close to real-world practice. However, this may indicate high risk of bias. Preeclampsia, hemostatic disorders, hypertension, diabetes mellitus, morbid obesity, or underweight were exclusion criteria in most studies. Patients with predictable abnormal blood loss and blood transfusions were typically excluded, although this category is most in need of prevention and correction of IPH, including in PACU. Only one study examined various methods of warming for women who experienced massive PPH during emergency CS [45].

Women with multiple pregnancies were included in only four studies [12, 15, 16, 40]. Multiple pregnancy is known to be a risk factor of PPH. Anemia before delivery was considered in only 5 publications [2, 16, 31, 37, 41].

Anesthetic methods

SA was used in more than half of the studies (55%). Six studies examined any method of anesthesia, including various types of regional anesthesia, as well as general anesthesia (GA) [4, 10, 12, 15, 16, 41]. Finally, two studies included abdominal delivery under GA only [33, 45] **(Fig. 5)**. Among local anesthetics, hyperbaric bupivacaine was the most common **(Fig. 6)**. Intrathecal morphine is known to significantly worse IPH [45]. Adjuvants are shown in **Fig. 7**.

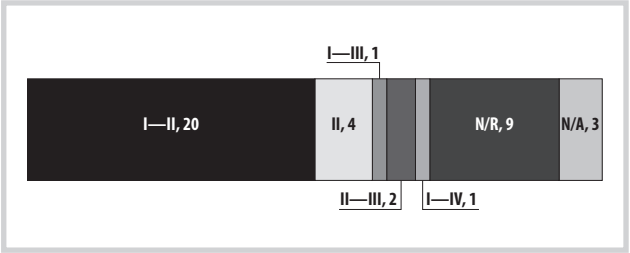

Fig. 4. **ASA classes in various studies.**
The diagram shows ASA classes I—IV; number of reports. N/R — not reported; N/A — not applicable.

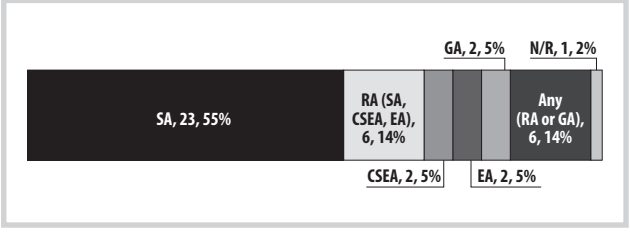

Fig. 5. **Types of anesthesia in various studies.**
The diagram shows type of anesthesia; number of studies; %. SA — spinal anesthesia; RA — regional anesthesia; EA — epidural anesthesia; CSEA — combined spinal-epidural anesthesia; GA — general anesthesia; N/R — not reported.

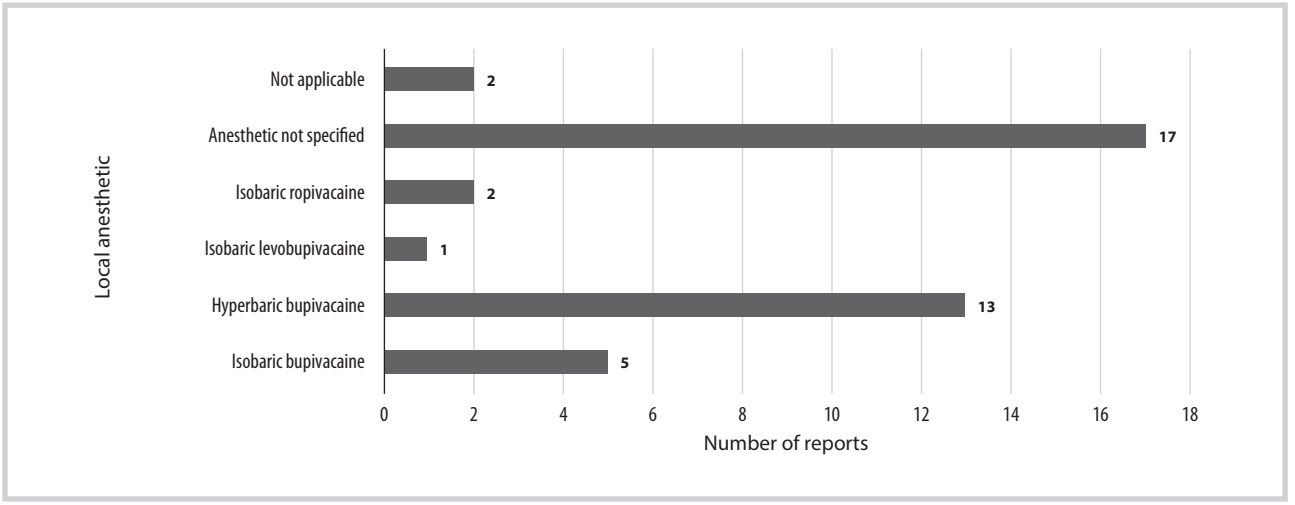

Fig. 6. **Local anesthetics for regional anesthesia.**

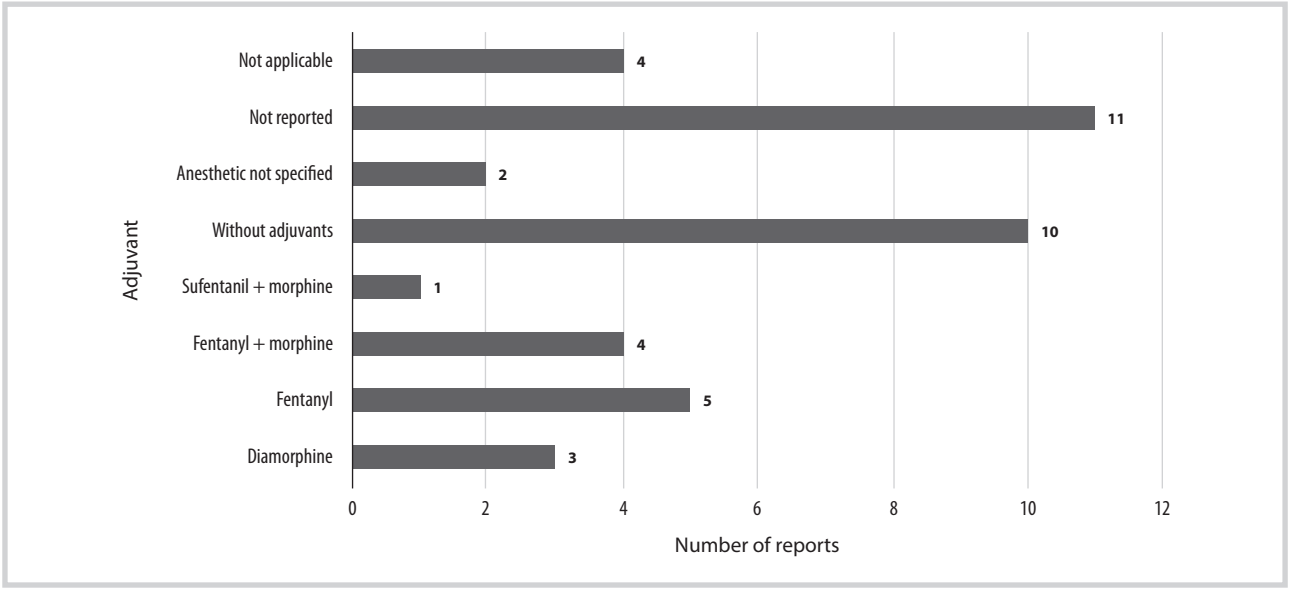

Fig. 7. **Adjuvants in regional anesthesia.**

IPH incidence

IPH incidence was recorded in 72% of studies. Of these, 11 RCTs compared hypothermia rates in active rewarming group(s) and control group **(Table 8)** [13—17, 19, 21, 24, 26, 28, 29].

Data on the incidence of IPH were heterogeneous, but all sources noted lower incidence of hypothermia for CS with active warming.

Thermal comfort assessment

Hypothermia affects not only objective body temperature but also subjective sensation of thermal comfort. Thermal comfort assessment and incidence of cold shivering are provided in more than half of the studies **(Table S5, QR code)**. The NICE guidelines (2016) state that active rewarming is advisable for surgeries lasting over 30 min [48]. In our review, CS time was taken into account in more than half of the studies and ranged

Table 8. **Incidence of inadvertent hypothermia in RCTs**

No.	RCT	IPH incidence, %	
		active warming group	group without active warming
1	Haim, 2024 [13]	6	6
2	Akdag Topal, 2024 [24]	15	58
3	Cotoia, 2021 [26]	4 and 0	47
4	Ni, 2020 [28]	20.6	51.6
5	Jun, 2019 [29]	0	48
6	Cobb, 2016 [14]	64	91
7	Duryea, 2016 [15]	69	77
8	Chakladar, 2014 [16]	5.2	19.0
9	Paris, 2014 [17]	38.4 and 48.0	65.7
10	Goyal, 2011 [19]	40.6	75.0
11	Butwick, 2007 [21]	53.3	66.6

from 30 to 72 min. This undoubtedly influenced the incidence of IPH. Zhang R. et al. [39] used a regression model to demonstrate that every 10-min increase in emergency CS time increases the likelihood of IPH (OR 1.97, 95% CI 1.24—3.11, p=0.004). Length of PACU-stay was recorded in only 18% of publications. However, no hypothermia is one of the criteria for discharge from PACU.

Blood loss and transfusion rate

Blood loss was analyzed in more than half of the studies, while the incidence of PPH was considered in only 4 reports [16, 37, 41, 45]. This may be explained by the adopted exclusion criterion for patients with predictable abnormal blood loss (placenta previa, placenta accreta spectrum, premature detachment of normal placenta, preeclampsia, hemostatic defects, multiple pregnancies). No studies assessed the incidence of coagulopathic bleeding.

Only 5 studies assessed hemoglobin decrease in early postpartum period compared to baseline values [2, 16, 37, 41, 47]. Chakladar A. et al. [16] reported less severe anemia following active intraoperative warming of patients using conductive mattress. The incidence of blood transfusions was noted in only 2 studies [16, 34]. Chakladar A. et al. [16] described 5 patients who required transfusions (in active warming and control groups) due to massive PPH (4000, 2500, and 2000 ml). Another study indicated that only one patient required blood transfusion. She was excluded from analysis later [27].

Postpartum infectious complications

Only five studies recorded the incidence of postpartum infections (endometritis, wound infection) [15, 31, 42, 46, 47]. This is due to low incidence of infectious complications in population of initially healthy mothers.

Prevention/correction of IPH in vaginal births

There are few data on prevention/correction of hypothermia following vaginal births. Among 2 articles, one manuscript is a case report [47]. A 14-year-old woman developed hypothermia after large-volume infusion of room-temperature solutions for correction of fluid and electrolyte balance without abnormal blood loss. Another study noted multifactorial nature of shivering in postpartum period [38]. Shivering can be caused by hypothermia accompanied by vasoconstriction and action of catecholamines resulting from pain or anxiety. According to the authors, shivering was observed in 16% of women in labor, but only in 28% of women it was not associated with hypothermia.

Discussion

To our knowledge, this is the first ScR on this issue. A great number of studies over the past 5 years indicates significant interest among researchers and clinicians in choosing optimal methods for prevention and correction of IPH in obstetrics. Although CS is a relatively short procedure, there is a risk of hypothermia [20]. We found no original Russian studies on this issue.

In most studies, the authors used definition of IPH provided in the NICE guidelines (2016) and extrapolated to obstetric population [48]. Currently, there is no a special document devoted to prevention and correction of IPH in obstetrics. Core temperature<36 °C but >35 °C is sufficient for adverse effects. Therefore, most perioperative studies use CBT<36 °C as a cut-off point [3].

The incidence of IPH varied across all studies that could be explained by heterogeneous groups. Indeed, there were patients with different types of anesthesia, body mass index, ASA class, elective and emergency CS with various blood losses and surgery time. In some studies, warming of infusion solutions was considered a passive rewarming method and used in both groups [16, 22, 23, 31, 32, 42]. This method may be particularly effective for CS due to relatively large infusion volumes [11].

An ideal strategy for preventing IPH in obstetric practice has not yet been developed. Convective blankets or their combination with warming of infusion solutions were the most common in all studies. Preoperative oral carbohydrate loading is widely used as a component of ERAS, including obstetric practice [51, 52]. However, the role of nutrient-induced thermogenesis in prevention of hypothermia during CS and vaginal delivery remains largely unexplored. This is somewhat unusual compared to physical rewarming methods, but ScR format allows for broad coverage (as opposed to specific issues addressed by meta-analyses).

Proactive management of body temperature implies the earliest possible active rewarming, especially when abnormal blood loss is predicted. This includes elective CS in women with placenta previa, PAS, multiple pregnancies, preeclampsia and hemostatic defects, as well as in case of expectable prolonged surgery. In our ScR, women with such conditions were excluded. Chung S-H. et al. [18] believed that preoperative rewarming is more important than intraoperative rewarming, and rewarming of the upper body is more effective than the lower body. Prewarming has virtually no effect on core body temperature but significantly increases shell temperature reducing the gradient and heat redistribution after induction of anesthesia.

There are few studies on emergency CS, as this category of women in labor is very difficult to prepare, recruit and study [41]. Heat loss in these patients is expectedly greater due to prolonged surgery, possible conversion of regional to general anesthesia, blood loss and increased infusion volumes. Furthermore, prewarming is unavailable to these patients due to logistical constraints.

In surgical patients, even mild hypothermia increases blood loss by 16% and the need for blood transfusions by 22% [53]. Another study found that decrease of body temperature by 1.6 °C increased blood loss by 30% [54]. Chakladar A. et al. [16] revealed more significant decrease of hemoglobin in women in labor without active warming. Yokoyama K. et al. [2] found lower blood loss and less severe anemia in the group of warmed infusion solutions. The authors suggested that warming of solutions, normal clotting, good uterine contractility and normothermia contributed to less blood loss.

Intraoperative warming of patients was the most common in our studies. Toit L. et al. [37] challenge current recommendations (NICE, 2016) and prescribe active warming only for surgeries lasting longer than 30 min. The authors showed that patients undergoing CS are subject to core temperature decrease for 60 min before onset of thermal restoration. This indicates the need to continue active warming in PACU and may be par-

ticularly relevant in patients with abnormal blood loss. Multimodal active rewarming strategies in pre-, intra- and postoperative period are optimal.

As early as 2006, Hui C.K. et al. [55] demonstrated that intrathecal morphine administration during CS caused more severe hypothermia compared to the control group. Intrathecal opioids can alter threshold levels of thermoregulatory centers, but their effect on thermoregulation in available RCTs is unclear. Indeed, opioids were used in various doses, alone and combined manner. Furthermore, Munday J. et al. [56] refute the conclusion that intrathecal morphine leads to more severe hypothermia during CS.

Most studies included healthy patients (ASA class ⩽ II). Obviously, women with higher risk of anesthesia have higher risk of hypothermia. On the other hand, greater benefits can be achieved with timely multimodal active rewarming.

Further studies are needed to identify women at higher risk of hypothermia and to examine the impact of IPH on adverse maternal outcomes, including PPH, blood transfusions, thrombotic complications and shock. Patients with high risk of PPH, multiple pregnancies, emergency CS and multimodal active rewarming strategies should be included in analysis.

There are few data on IPH following vaginal birth. The causes of hypothermia in postpartum period are numerous: hypovolemia due to hemorrhage, aggressive fluid therapy and administration of drugs during labor (e.g., oxytocin and magnesium sulfate) [47]. Careful temperature monitoring in labor and early postpartum period, implementation of local protocols for prevention and correction of hypothermia are essential.

There are certain strengths of this review. First, a systematic searching of sources was conducted in more than two databases. Second, modern ScR management tools minimized errors in processing a large dataset. Third, the results are presented using modern visualization tools in accordance with the JBI methodology.

Study limitations

Our results are applicable only to patients undergoing CS due to few data on prevention and correction of hypothermia during vaginal births. Second, sample sizes in available RCTs likely did not provide sufficient power to detect significant between-group differences in such important indicators as blood loss, transfusion rate and hemoglobin gradient.

Conclusion

Multimodal active rewarming strategies in pre-, intra- and postoperative period are optimal. The impact of inadvertent hypothermia on blood loss in context of postpartum hemorrhage remains largely unstudied. Perhaps, assessing the impact of inadvertent hypothermia in patients with postpartum hemorrhage on blood loss, coagulation factor requirements and blood transfusions will allow hypothermia to be considered as a factor in severe obstetric blood loss. Further research is needed to understand the complications and adverse outcomes associated with inadvertent hypothermia in obstetric patients.

Author contribution:
Concept and design of the study — Barkovskaya N.A., Shifman E.M.
Collection and analysis of data — Barkovskaya N.A., Protsenko D.N., Katkova N.Yu.
Data analysis — Barkovskaya N.A., Shifman E.M., Lebedinskii K.M.
Writing — Barkovskaya N.A..
Editing — Shifman E.M., Lebedinskii K.M.

No conflict of interests to declare.

Link for viewing additional materials:
https://www.mediasphera.ru/upload/medialibrary/files/Anestesiolog_Barkovskaya_2026_02_app_EN.pdf

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Received 07.09.2025
Accepted 09.11.2025