ISSN 3063-8089 (Online)
Adult Health Nursing Journal
Volume 3 Issue 1, Pages: 24-32
Publish June 2026

ORIGINAL ARTICLE

Enhancing Thermal Comfort Through Hand Warmer Application in Patients Undergoing Regional Anesthesia: A Pre-Experimental Study

Muhammad Hirzi Syafiqri[1]*, Aisyah Nur Azizah[2], Triyas Singgih Pambudi[3]

[1] Universitas 'Aisyiyah Yogyakarta, Indonesia
[2] Universitas 'Aisyiyah Yogyakarta, Indonesia
[3] Universitas 'Aisyiyah Yogyakarta, Indonesia
* Corresponding Author: mhirzisyafiqri@gmail.com

ARTICLE INFORMATION

Article history
Received: 2026/05/21
Revised : 2026/06/01
Accepted: 2026/06/05

Keywords
Regional Anesthesia; Thermal Comfort; Perioperative Nursing; Hypothermia; Warming Intervention; Preoperative Care

How to cite
Syafiqri, M. H., Azizah, A. N., & Pambudi, T. S. (2026). Enhancing Thermal Comfort Through Hand Warmer Application in Patients Undergoing Regional Anesthesia: A Pre-Experimental Study. *Adult Health Nursing Journal*, *3*(1), 24–32. https://doi.org/10.33650/ahnj.v3i1.15524

ABSTRACT

Background: *Patients undergoing regional anesthesia are frequently exposed to low perioperative ambient temperatures before surgery, increasing the risk of thermal discomfort even in the absence of overt hypothermia. Although perioperative warming strategies have been widely discussed, evidence regarding simple localized warming interventions during the pre-anesthetic phase remains limited, particularly in relation to subjective thermal comfort.* ***Objective:*** *To examine the effect of hand warmer application on thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase.* ***Methods:*** *A pre-experimental study with a one-group pretest–posttest design was conducted at PKU Muhammadiyah Bantul Hospital, Indonesia. Thirty patients scheduled for regional anesthesia were recruited using purposive sampling. Thermal comfort was assessed before and after intervention using the Thermal Comfort Scale (TCS). Participants received localized warming through hand warmer application on the palmar area for 10 minutes during the pre-anesthetic waiting period. Data were analyzed using the Wilcoxon signed-rank test with a significance level of $p < 0.05$.* ***Results****: Prior to the intervention, most participants reported neutral (43.3%) or uncomfortable (40.0%) thermal sensations. Following hand warmer application, thermal comfort shifted entirely toward comfortable (73.3%) and very comfortable (26.7%) categories. Wilcoxon signed-rank analysis demonstrated a statistically significant improvement in thermal comfort scores after the intervention ($Z = -4.861$, $p < 0.001$). No participants reported worsening thermal comfort following localized warming.* ***Conclusion****: Hand warmer application improved subjective thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase. As a simple, low-cost, and non-invasive intervention, localized peripheral warming may support more patient-centered perioperative nursing care and enhance pre-anesthetic comfort management.*

Adult Health Nursing Journal is a peer-reviewed journal published by Fakultas Kesehatan, Universitas Nurul Jadid, Probolinggo, East Java.
Website: https://fkes.unuja.ac.id
E-mail: adulthealthnurse@gmail.com
DOI : https://doi.org/10.33650/ahnj.v3i1.15524

This is an open access article under the CC BY-NC-SA 4.0 license

A. Introduction

Surgical procedures remain an essential part of modern healthcare because many diseases still require invasive intervention to achieve definitive treatment (Meara et al., 2015). Although surgical and anesthetic techniques continue to advance, perioperative complications remain common in clinical practice (Rauch et al., 2021). One of the most frequently reported

complications is inadvertent perioperative hypothermia, defined as a decrease in core body temperature below 36°C from the pre-anesthetic period until the first 24 hours after surgery (NICE, 2016). Heat loss during the perioperative phase may result from impaired thermoregulation caused by anesthesia, redistribution of body heat to peripheral tissues, exposure to low ambient temperatures, administration of unwarmed intravenous fluids, and exposure of body surfaces during surgery (Riley & Andrzejowski, 2018).

Patients undergoing regional anesthesia remain at risk of perioperative heat loss (Mendonça et al., 2021). Sympathetic blockade during spinal or epidural anesthesia causes peripheral vasodilation, allowing heat to shift more easily from the body core to peripheral tissues (Munday et al., 2023). Previous studies have reported that hypothermia may still occur in patients receiving regional anesthesia, including during relatively short surgical procedures (Yüksek et al., 2020). Temperature management therefore remains important even when patients remain conscious throughout the procedure (Babiker Mohamed et al., 2022).

In addition to physiological heat loss, patients receiving regional anesthesia frequently report cold sensation during the perioperative period (Gustafsson et al., 2021). Complaints often begin while patients wait in pre-anesthetic rooms with relatively low ambient temperatures (Yuan et al., 2022). Although core body temperature may still remain within the normal range, prolonged exposure to cold environments can increase discomfort and anxiety before surgery (Wang et al., 2022). These sensations are often perceived more clearly because patients remain conscious during regional anesthesia (Sessler, 2008).

Thermal comfort is not limited to maintaining normal body temperature but also involves the patient's subjective perception of warmth and environmental comfort (ASHRAE, 2023; Yang et al., 2024). Physical and psychological factors, including anxiety, stress, and perceived safety, may influence thermal perception during the perioperative period (Gustafsson et al., 2021; Tian, 2023). Several studies have shown that thermal discomfort may negatively affect perioperative experience and patient satisfaction(Carvalho et al., 2024; Gustafsson et al., 2021; Palmer et al., 2019). Maintaining thermal comfort has therefore become an important component of patient-centered perioperative nursing care (Carvalho et al., 2024; Palmer et al., 2019; Yuan et al., 2022).

Perioperative hypothermia may lead to several adverse clinical outcomes, including shivering, increased oxygen consumption, coagulation impairment, delayed anesthetic recovery, and higher risk of surgical site infection (Madrid et al., 2016; Rauch et al., 2021; Sessler, 2016). In some patients, hypothermia may also increase cardiovascular workload and prolong hospitalization (Riley & Andrzejowski, 2018; Sessler, 2016). These complications have made perioperative temperature management an important part of anesthetic and perioperative nursing practice (Babiker Mohamed et al., 2022; NICE, 2016; Simegn et al., 2021).

Various warming methods have been introduced to reduce perioperative heat loss, including forced-air warming systems, thermal blankets, and warmed intravenous fluids (Madrid et al., 2016; Rauch et al., 2021; Simegn et al., 2021). Although these approaches are effective in maintaining core temperature, their use during short pre-anesthetic waiting periods may be less practical because they often require additional equipment and preparation (Ji et al., 2024; Riley & Andrzejowski, 2018). Most previous studies have also focused primarily on physiological outcomes such as temperature maintenance and hypothermia prevention rather than patients' subjective thermal comfort (Carvalho et al., 2024; Gustafsson et al., 2021; Yuan et al., 2022).

The pre-anesthetic phase may be particularly vulnerable because patients are exposed to cold environments while simultaneously experiencing anxiety before surgery (Bello et al., 2025; Gustafsson et al., 2021; Rauch et al., 2021). During this period, patients may already feel uncomfortable despite remaining normothermic. Studies exploring simple interventions to improve thermal comfort before anesthesia induction remain limited in perioperative nursing practice(ASHRAE, 2023; Gustafsson et al., 2021; Wang et al., 2022).

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

Hand warmers may provide a practical approach for localized warming during the pre-anesthetic phase (ALP, 2024; Ji et al., 2024). They are portable, inexpensive, non-invasive, and easy to use in routine clinical settings (ALP, 2024; Mauk et al., 2024). Warming the hands may also improve overall warmth perception because peripheral thermal sensation contributes to subjective comfort (Wang et al., 2022; Yang et al., 2024). Despite their widespread use for personal thermal support, the use of hand warmers in perioperative care has received limited attention, particularly among patients undergoing regional anesthesia (Carvalho et al., 2024; Ji et al., 2024; Simegn et al., 2021).

Preliminary observations at PKU Muhammadiyah Bantul Hospital showed that patients undergoing regional anesthesia commonly waited for approximately 30–60 minutes in pre-anesthetic rooms with relatively low ambient temperatures before surgery. During this period, several patients reported cold sensation and discomfort despite stable hemodynamic conditions and absence of overt hypothermia. Current management is generally limited to blanket use or warmed intravenous fluids once discomfort becomes more noticeable.

This study aimed to analyze the effect of hand warmer application on thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase at PKU Muhammadiyah Bantul Hospital. The study focused on a simple intervention that could be easily incorporated into routine perioperative nursing care to improve patient comfort before surgery.

B. Methods

This study employed a quantitative pre-experimental approach with a one-group pretest–posttest design to evaluate changes in thermal comfort before and after a localized warming intervention. The study was conducted in the pre-anesthetic unit of PKU Muhammadiyah Bantul Hospital, Indonesia, involving patients scheduled for elective surgery under regional anesthesia.

Participants were selected using purposive sampling. Eligible patients were aged 17–59 years, scheduled for spinal, epidural, or caudal anesthesia, classified as ASA physical status I–II, conscious, cooperative, able to communicate effectively, and willing to provide written informed consent. Patients were excluded if they had maximal baseline thermal comfort, underwent general or combined anesthesia, had impaired consciousness, or had conditions affecting thermoregulation, including diabetes mellitus, neurological disorders, endocrine disorders, or fever.

The final target sample was 33 participants, including an additional 10% to anticipate incomplete data. The intervention consisted of applying one commercially available air-activated hand warmer to the palmar area for 10 minutes during the pre-anesthetic waiting period. Thermal comfort was measured before and immediately after the intervention using the Thermal Comfort Scale, a five-point ordinal scale ranging from −2 to +2. Body temperature and participant characteristics were also recorded.

Data were analyzed using IBM SPSS Statistics. Descriptive statistics summarized participant characteristics, while pre- and post-intervention thermal comfort scores were compared using the Wilcoxon signed-rank test because the data were ordinal and paired. Statistical significance was set at $p < 0.05$. Ethical approval was obtained from the Ethics Committee of PKU Muhammadiyah Bantul Hospital No. 003/EC.KEPK/C/01.26, and all participants provided written informed consent.

C. Results

A total of 30 patients undergoing regional anesthesia were included in the analysis. Participants were predominantly female (60.0%), and the largest age group was 26–35 years (36.7%). Most participants had normal body mass index values (86.7%) and were classified as

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

ASA physical status II (73.3%). Mild and moderate preoperative anxiety levels were each observed in 30.0% of participants.

Before the intervention, thermal comfort during the pre-anesthetic waiting period was generally low. Most participants reported neutral (43.3%) or uncomfortable (40.0%) thermal sensations, while 10.0% described themselves as very uncomfortable. Only two participants (6.7%) reported feeling comfortable prior to hand warmer application.

Following the intervention, thermal comfort scores shifted markedly toward warmer comfort categories. Most participants reported feeling comfortable (73.3%), whereas 26.7% reported being very comfortable. No participants remained in the neutral or uncomfortable categories after the intervention. This pattern indicates a consistent improvement in subjective thermal comfort during the pre-anesthetic phase.

Wilcoxon signed-rank analysis demonstrated a statistically significant difference between pre- and post-intervention thermal comfort scores ($Z = -4.861$, $p < 0.001$). All participants showed positive changes in thermal comfort following hand warmer application, with no negative ranks identified.

Table 1: Participant Characteristics

Variable	Category	n	(%)
Age (years)	17–25	3	10.0
	26–35	11	36.7
	36–45	7	23.3
	46–59	9	30.0
Sex	Male	12	40.0
	Female	18	60.0
Body Mass Index	Underweight	2	6.7
	Normal	26	86.7
	Overweight	1	3.3
	Obesity	1	3.3
ASA Physical Status	ASA I	8	26.7
	ASA II	22	73.3
APAIS Anxiety Score	1–6 (No anxiety)	5	16.7
	7–12 (Mild anxiety)	9	30.0
	13–18 (Moderate anxiety)	9	30.0
	19–24 (Severe anxiety)	7	23.3

Abbreviations: ASA, American Society of Anesthesiologists; APAIS, Amsterdam Preoperative Anxiety and Information Scale.

The study population was dominated by relatively stable perioperative patients, as reflected by the predominance of ASA II status and normal body mass index. Despite this relatively stable clinical profile, varying levels of preoperative anxiety were still observed, suggesting that psychological discomfort remained common during the pre-anesthetic phase.

Table 2: Distribution of Thermal Comfort Scores Before and After Hand Warmer Application

Thermal Comfort Category	Pre-Intervention		Post-Intervention	
	n	(%)	n	(%)
Very uncomfortable	3	10.0	0	0.0
Uncomfortable	12	40.0	0	0.0
Neutral	13	43.3	0	0.0
Comfortable	2	6.7	22	73.3
Very comfortable	0	0.0	8	26.7

Thermal comfort distribution changed substantially following the intervention. Before hand warmer application, most participants reported neutral or cold discomfort sensations. After the intervention, all participants transitioned into comfortable or very comfortable categories, indicating a clear shift toward improved subjective thermal perception during the pre-anesthetic waiting period.

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

Table 3: Wilcoxon Signed-Rank Test for Thermal Comfort Scores

Intervention Phase	Very Comfortable (+2)		Comfortable (+1)		Neutral (0)		Uncomfortable (−1)		Very Uncomfortable (−2)		Z	p-value
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)		
Pre-intervention	0	0.0	2	6.7	13	43.3	12	40.0	3	10.0	−4.861	<0.001
Post-intervention	8	26.7	22	73.3	0	0.0	0	0.0	0	0.0		

Thermal comfort scores improved substantially after hand warmer application. Before the intervention, most participants reported neutral or uncomfortable thermal sensations, whereas post-intervention responses shifted entirely toward comfortable and very comfortable categories. Wilcoxon signed-rank analysis demonstrated a statistically significant difference between pre- and post-intervention thermal comfort scores ($Z = -4.861$, $p < 0.001$). All participants showed positive changes in thermal comfort, with no negative ranks observed, indicating a consistently favorable response to the warming intervention during the pre-anesthetic phase.

D. Discussion

This study demonstrated that hand warmer application significantly improved thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase. Before the intervention, most participants reported neutral-to-cold thermal sensations despite remaining clinically stable and normothermic. Following 10 minutes of localized warming, thermal comfort shifted entirely toward comfortable and very comfortable categories. These findings indicate that subjective thermal discomfort may emerge before overt perioperative hypothermia develops and that simple peripheral warming can meaningfully improve patient comfort during perioperative preparation (Sessler, 2016; Rauch et al., 2021).

The improvement observed in this study appears closely related to the physiological vulnerability associated with regional anesthesia. Sympathetic blockade induced by spinal or epidural anesthesia promotes peripheral vasodilation and accelerates redistribution of heat from the core to peripheral tissues (Sessler, 2008). In cold perioperative environments, this redistribution process increases patients' susceptibility to thermal discomfort even before measurable reductions in core temperature occur (Riley & Andrzejowski, 2018). Within this context, localized warming through hand warmer application likely reduced peripheral cold sensation by stimulating cutaneous thermoreceptors and enhancing warmth perception at the sensory level. Because thermal comfort is strongly influenced by subjective perception rather than body temperature alone, improving peripheral warmth may contribute substantially to patients' overall perioperative comfort experience (ASHRAE, 2023; Wang et al., 2022).

These findings are consistent with previous perioperative warming studies reporting that active warming interventions improve patient comfort and reduce cold-related perioperative symptoms. Carvalho et al. (2024) demonstrated that thermal insulation strategies contributed not only to temperature maintenance but also to improved patient-reported comfort during surgery. Similarly, Ji et al. (2024) emphasized that perioperative warming interventions are clinically beneficial even in patients without severe hypothermia because early warming may reduce thermal stress and improve perioperative adaptation. More broadly, phenomenological research by Gustafsson et al. (2021) showed that patients often perceive warmth and coldness as emotionally meaningful experiences during surgery, suggesting that thermal comfort should be considered part of patient-centered perioperative care rather than merely a physiological outcome.

The present study differs from many previous investigations that primarily focused on core temperature maintenance, intraoperative warming systems, or prevention of postoperative hypothermia (Madrid et al., 2016; Simegn et al., 2021). The current findings extend existing evidence by demonstrating that a simple non-pharmacological intervention applied during the

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

pre-anesthetic waiting period may improve subjective thermal comfort even before anesthesia induction. This distinction is clinically important because patients may already experience discomfort, anxiety, and physiological stress while still classified as normothermic. As a result, thermal comfort may function as an early patient-reported indicator of perioperative wellbeing that deserves greater attention in perioperative nursing practice (Yang et al., 2024).

Psychological factors may also have contributed to the observed improvement in thermal comfort. Most participants in this study experienced mild-to-moderate preoperative anxiety. Anxiety activates sympathetic responses that increase physiological tension and may heighten sensitivity to environmental discomfort, including cold exposure (Bello et al., 2025). In conscious patients undergoing regional anesthesia, these sensations may become more apparent because patients remain fully aware of the surrounding environment throughout perioperative preparation. The warming sensation provided by hand warmers may therefore have produced not only peripheral thermal effects but also a calming sensory stimulus that reduced discomfort perception during the waiting period.

From a clinical perspective, the findings support the potential integration of simple warming interventions into routine perioperative nursing care. Hand warmers offer several practical advantages, including portability, low cost, ease of application, and minimal equipment requirements (Alp, 2024). Compared with forced-air warming systems or electrically heated devices, localized hand warming may be more feasible during short preoperative waiting periods or in settings with limited resources. In perioperative nursing practice, interventions that directly improve patient comfort while remaining simple and scalable may contribute positively to patient experience and quality of care (Tian, 2023). Moreover, current perioperative hypothermia guidelines increasingly emphasize the importance of early warming strategies and preventive thermal management before anesthesia induction (NICE, 2016; Babiker Mohamed et al., 2022).

Several limitations should nevertheless be acknowledged. The study used a one-group pretest–posttest design without a control group, limiting causal inference and increasing susceptibility to environmental or psychological confounding factors. The relatively small sample size and single-center setting may also restrict generalizability to broader perioperative populations. In addition, thermal comfort was assessed using subjective self-reported measures without continuous monitoring of core temperature changes. Although subjective comfort represents an important patient-centered outcome, combining perceptual and physiological measurements in future studies would strengthen the interpretation of warming effects.

Future research should consider randomized controlled designs comparing different warming modalities, durations, or warming locations during the perioperative phase. Studies involving larger and more diverse surgical populations may also help clarify whether peripheral warming interventions influence additional outcomes such as perioperative anxiety, shivering incidence, physiological stability, or postoperative recovery quality. More detailed investigation into the interaction between subjective thermal comfort and perioperative psychological responses may further contribute to the development of holistic patient-centered warming strategies in perioperative nursing care.

Implication and limitation

The findings of this study indicate that hand warmer application may represent a simple, low-cost, and practical non-pharmacological warming intervention to improve thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase. By enhancing subjective warmth perception, this intervention may support patient-centered perioperative nursing care and help reduce discomfort associated with exposure to cold perioperative environments. Nevertheless, several limitations should be considered. The use of a one-group pretest–posttest design without a control group limits causal interpretation, while the relatively small sample size and single-center setting may reduce the generalizability of the findings. In addition, thermal comfort was assessed primarily through subjective patient-

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

reported measures without continuous physiological temperature monitoring. Future studies using randomized controlled designs with larger and more diverse populations are therefore needed to further clarify the effectiveness of localized warming interventions in perioperative care.

Relevance for Practice

The present findings support the integration of simple peripheral warming interventions into routine perioperative nursing care, particularly during the pre-anesthetic phase of regional anesthesia. Hand warmer application may help improve patients' subjective thermal comfort, reduce cold-related discomfort, and enhance overall perioperative experience without requiring complex equipment or substantial additional resources. As a portable, inexpensive, and non-invasive intervention, hand warmers may be especially applicable in perioperative settings with limited warming facilities or high patient turnover, thereby contributing to more patient-centered and comfort-oriented anesthesia care.

E. Conclusion

Hand warmer application was associated with a significant improvement in thermal comfort among patients undergoing regional anesthesia during the pre-anesthetic phase. The provision of localized peripheral warming appeared to reduce cold-related discomfort and promote a more comfortable perioperative experience before anesthesia induction. In the context of perioperative nursing care, these findings reinforce the importance of early thermal support, even in patients who remain normothermic. Given its simplicity, low cost, and ease of implementation, hand warmer use may offer a practical approach to enhancing patient-centered comfort management in routine perioperative practice.

Acknowledgment

The authors would like to express their sincere gratitude to RS PKU Muhammadiyah Bantul for providing permission and support during the research process. Appreciation is also extended to all patients who voluntarily participated in this study and to the perioperative nursing staff who assisted with data collection and intervention implementation.

Author Contribution

Muhammad Hirzi Syafiqri contributed to study conceptualization, data collection, intervention implementation, data analysis, and manuscript drafting. Aisyah Nur Azizah contributed to research supervision, methodological development, critical revision of the manuscript, and interpretation of findings. Triyas Singgih Pambudi contributed to study design, statistical consultation, manuscript review, and final approval of the submitted version. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

Funding

This research received no external funding.

Declaration of Conflicting Interest

The authors declare no conflict of interest.

Declaration of Use of AI in Scientific Writing

The authors declare that generative AI and AI-assisted technologies were used to support language editing and grammatical refinement of the manuscript.

References

ALP, F. B. (2024). Hand warmer types, silica and zeolite 4A as potential hand warmers. *Sigma Journal of Engineering and Natural Sciences – Sigma Mühendislik ve Fen Bilimleri Dergisi*, *42*(2), 356–365. https://doi.org/10.14744/sigma.2024.00035

ASHRAE. (2023). *ANSI/ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*. ASHRAE. https://www.ashrae.org/technical-resources/bookstore/standard-55-thermal-environmental-conditions-for-human-occupancy

Babiker Mohamed, M. A., Abdelwahab Abdelkarim, W. A., Salih Aabdeen, M. A., Elobid Ahmed, T. H., Sarsour,

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

H. H. H., El-Malky, A. M., Amer, Y. S., Alsaleh, N., & Nazer, R. I. (2022). Evidence-based clinical practice guidelines for the management of perioperative hypothermia: Systematic review, critical appraisal, and quality assessment with the AGREE II instrument. *Annals of Medicine and Surgery (2012)*, *79*, 103887. https://doi.org/10.1016/j.amsu.2022.103887

Bello, C. M., Eisler, P., & Heidegger, T. (2025). Perioperative Anxiety: Current Status and Future Perspectives. *Journal of Clinical Medicine*, *14*(5). https://doi.org/10.3390/jcm14051422

Carvalho, I., Carvalho, M., Abelha, F., & Martins, T. (2024). Effectiveness of a new thermal insulation blanket in the control of inadvertent perioperative hypothermia and comfort: a randomized controlled trial. *BMC Anesthesiology*, *24*(1), 455. https://doi.org/10.1186/s12871-024-02830-0

Gustafsson, I. L., Rask, M., Schildmeijer, K., & Elmqvist, C. (2021). Patients experience of warmth and coldness in connection with surgery - a phenomenological study. *International Journal of Qualitative Studies on Health and Well-Being*, *16*(1), 1858540. https://doi.org/10.1080/17482631.2020.1858540

Ji, N., Wang, J., Li, X., & Shang, Y. (2024). Strategies for perioperative hypothermia management: advances in warming techniques and clinical implications: a narrative review. *BMC Surgery*, *24*(1), 425. https://doi.org/10.1186/s12893-024-02729-0

Madrid, E., Urrútia, G., Roqué i Figuls, M., Pardo-Hernandez, H., Campos, J. M., Paniagua, P., Maestre, L., & Alonso-Coello, P. (2016). Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *The Cochrane Database of Systematic Reviews*, *4*(4), CD009016. https://doi.org/10.1002/14651858.CD009016.pub2

Mauk, M. G., Ansah, F., & El-Tholoth, M. (2024). Chemical Heating for Minimally Instrumented Point-of-Care (POC) Molecular Diagnostics. *Biosensors*, *14*(11). https://doi.org/10.3390/bios14110554

Meara, J. G., Leather, A. J. M., Hagander, L., Alkire, B. C., Alonso, N., Ameh, E. A., Bickler, S. W., Conteh, L., Dare, A. J., Davies, J., Mérisier, E. D., El-Halabi, S., Farmer, P. E., Gawande, A., Gillies, R., Greenberg, S. L. M., Grimes, C. E., Gruen, R. L., Ismail, E. A., … Yip, W. (2015). Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet (London, England)*, *386*(9993), 569–624. https://doi.org/10.1016/S0140-6736(15)60160-X

Mendonça, F. T., Ferreira, J. D. S., Guilardi, V. H. F., & Guimarães, G. M. N. (2021). Prevalence of Inadvertent Perioperative Hypothermia and Associated Factors: A Cross-Sectional Study. *Therapeutic Hypothermia and Temperature Management*, *11*(4), 208–215. https://doi.org/10.1089/ther.2020.0038

Munday, J., Delaforce, A., Heidke, P., Rademakers, S., Sturgess, D., Williams, J., & Douglas, C. (2023). Perioperative temperature monitoring for patient safety: A period prevalence study of five hospitals. *International Journal of Nursing Studies*, *143*, 104508. https://doi.org/https://doi.org/10.1016/j.ijnurstu.2023.104508

NICE. (2016). *Hypothermia: prevention and management in adults having surgery* (NICE Clini). National Institute for Health and Care Excellence (NICE). https://www.ncbi.nlm.nih.gov/books/NBK554181/

Palmer, J., Soucier, M., & Deeds, J. (2019). An innovative warming strategy to increase patient satisfaction. *Nursing*, *49*(7), 49–53. https://doi.org/10.1097/01.NURSE.0000559920.61696.84

Rauch, S., Miller, C., Bräuer, A., Wallner, B., Bock, M., & Paal, P. (2021). Perioperative Hypothermia-A Narrative Review. *International Journal of Environmental Research and Public Health*, *18*(16). https://doi.org/10.3390/ijerph18168749

Riley, C., & Andrzejowski, J. (2018). Inadvertent perioperative hypothermia. *BJA Education*, *18*(8), 227–233. https://doi.org/10.1016/j.bjae.2018.05.003

Sessler, D. I. (2008). Temperature monitoring and perioperative thermoregulation. *Anesthesiology*, *109*(2), 318–338. https://doi.org/10.1097/ALN.0b013e31817f6d76

Sessler, D. I. (2016). Perioperative thermoregulation and heat balance. *Lancet (London, England)*, *387*(10038), 2655–2664. https://doi.org/10.1016/S0140-6736(15)00981-2

Simegn, G. D., Bayable, S. D., & Fetene, M. B. (2021). Prevention and management of perioperative hypothermia in adult elective surgical patients: A systematic review. *Annals of Medicine and Surgery (2012)*, *72*, 103059. https://doi.org/10.1016/j.amsu.2021.103059

© The Author(s) 2026. Licensed under CC BY-NC-SA 4.0

Tian, Y. (2023). A review on factors related to patient comfort experience in hospitals. *Journal of Health, Population, and Nutrition*, *42*(1), 125. https://doi.org/10.1186/s41043-023-00465-4

Wang, Y., Lian, Z., & Chang, H. (2022). The correlation between the overall thermal comfort, the overall thermal sensation and the local thermal comfort in non-uniform environments with local cooling. *Indoor and Built Environment*, *31*(7), 1822–1833. https://doi.org/10.1177/1420326X221079819

Yang, Y., Lyu, J., Lian, Z., Xie, Y., Jiang, Y., Lin, J., & Niu, J. (2024). Subjective information in thermal comfort evaluation methods: A critical review. *Energy and Buildings*, *325*, 115019. https://doi.org/https://doi.org/10.1016/j.enbuild.2024.115019

Yuan, F., Yao, R., Sadrizadeh, S., Li, B., Cao, G., Zhang, S., Zhou, S., Liu, H., Bogdan, A., Croitoru, C., Melikov, A., Short, C. A., & Li, B. (2022). Thermal comfort in hospital buildings – A literature review. *Journal of Building Engineering*, *45*, 103463. https://doi.org/https://doi.org/10.1016/j.jobe.2021.103463

Yüksek, A., Talih, G., Kantekin, C. U., & Yardımcı, C. (2020). Perioperative temperature monitoring in general and neuraxial anesthesia: a survey study. *Ain-Shams Journal of Anesthesiology*, *12*(1), 12. https://doi.org/10.1186/s42077-020-00065-y

© *The Author(s) 2026. Licensed under CC BY-NC-SA 4.0*