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BODY TEMPERATURE MANAGEMENT IN PERIOPERATIVE AND INTENSIVE CARE: CLINICAL STRATEGIES FOR IMPROVING PATIENT OUTCOMES

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ABSTRACT

In perioperative and intensive care unit settings, body temperature management represents a fundamental aspect of patient supervision, profoundly influencing the efficacy of therapeutic interventions, the risk of complications, and overall patient prognosis. This study explores thermoregulatory mechanisms, the effects of temperature deviations, methods for controlled temperature modulation, while also addressing associated economic, sociological and ethical considerations. Based on the interpretation of available scientific evidence, it has been demonstrated that unmeasured temperature fluctuations constitute a fundamental challenge in the context of intensive care unit management and perioperative care, with their complications representing a critical factor in maintaining homeostasis. This work addresses the issue of technical temperature monitoring, the importance of an individualized approach to each clinical case, as well as the role of state-of-the-art technologies and their perception by patients and their relatives in life-threatening situations. Concurrently, it examines the expenditures associated with the use of cutting-edge technologies as a limiting factor in the widespread adoption of such procedures, potentially leading to inequalities in access to care and necessitating further economic considerations. The findings indicate that effective monitoring of core body temperature represents not only a fundamental element of clinical patient care but also a critical life-saving technology at the threshold of life and death. This review underscores the urgent need for comprehensive standards in thermoregulation and highlights the limitations of current clinical algorithms. These gaps call for rigorous randomized studies to refine existing protocols and ensure their reliability and efficacy in high-risk settings.

KEYWORDS

Targeted Temperature Management (TTM), Thermoregulation, Hypothermia, Hyperthermia, Neuroprotection

CITATION

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Introduction

Maintaining an appropriate body temperature is a key factor in preserving homeostasis and ensuring patient safety during hospitalization. This topic was first addressed in 1851 by the physician Carl Reinhold August Wunderlich, who established the initial temperature norm of 37˚C [1]. This standard was subsequently revised in 1992 by Mackowiak et al. [2], who lowered it to 36.8˚C. The findings of this study are still considered the physiological norm in contemporary medical sources, with an accepted range of 36.8 ± 0.5˚C [3]. The variation within this range reflects the natural physiological variability of the human body, in which continuous metabolic, hormonal, and numerous other processes occur, constantly adapting to the organism's current needs [4].

In the intensive care unit, a fundamental aspect of patient care involves maintaining vital functions and providing medical treatment, while also ensuring patient comfort, including optimal thermal status, overall health improvement and the maintenance of physiological capacity. The presence of a physician on a twenty-four-hour basis and the provision of psychological support to the patient also play a critical role [5,6]. Maintaining an appropriate body temperature is a key responsibility of the healthcare team; however, despite the availability of technologically advanced operating rooms and intensive care units, as well as the employment of highly qualified medical personnel, disturbances in patient thermoregulation remain a significant and widespread problem to this day. The aforementioned fluctuations in body temperature encompass both increases and decreases in its value. The occurrence of intraoperative hypothermia has been documented in studies from 2015 [7] and 2019 [8], reporting incidences of 39.9% and 78.6%, respectively. In contrast, it is estimated that elevated body temperature affects between 26-88% of patients in intensive care units [9], while as many as 11.6% of patients in these units following intra-abdominal surgery present with hyperthermia [10].

The aim of this study is to provide a comprehensive analysis of maintaining an appropriate range of body temperature in perioperative and intensive care units, taking into account both clinical indications and socio-economic considerations. The interdisciplinary nature of this study integrates medical aspects of managing hypothermia and hyperthermia, presents indications for deliberate intervention in the patient's body temperature, analyzes current guidelines, examines potential complications and side effects from a strictly scientific perspective. Additionally, it provides a humanistic reflection on the significance of decisions made by healthcare personnel, the physician–patient relationship and the rationale behind the selection of applied technologies. This comprehensive approach enables the integration of insights from medicine, bioethics, medical sociology, and nursing, offering a holistic perspective on the maintenance of normothermia. It considers not only the physiological aspects but also the ethical and social dimensions of patient care, while consistently upholding respect for patient autonomy.

Methodology

The presented analysis includes a review of the scientific literature on the significance of patient thermoregulation in perioperative and intensive care units, integrating the perspective of clinical sciences with a humanistic, ethical, and social reflection in the context of practical decision-making, and the experiences of patients and their families. The focus was primarily on identifying the most recent scientific sources published mostly over the past six years (2020–2025) in databases such as PubMed, Google Scholar, ScienceDirect, SpringerLink, as well as on the websites of international institutions and scientific societies, including the Polish Society of Anaesthesiology and Intensive Therapy. The following keywords were used for the search: "patient body temperature control", "human thermoregulation", "socio-economic factors", "postoperative hypothermia", "prevention of hyperthermia", and "normothermia". The study included review papers, original research and expert articles, as well as guidelines from scientific societies. Materials providing both empirical data and theoretical reflections were incorporated, enabling a comprehensive treatment regarding clinical sciences and a humanistic perspective, while preserving the interdisciplinary nature of the study.

Results

Physiological mechanisms of thermoregulation: clinical implications of hypothermia and hyperthermia

The regulation of human body temperature is a complex process, tightly controlled by the thermoregulatory center located in the preoptic area of the hypothalamus, which is a part of the brain's limbic system [3, 11]. Even minor deviations from the accepted normative range elicit the activation of protective mechanisms in accordance with the thermoregulatory requirements of the human body. These mechanisms are categorized as voluntary, behavioral responses—such as donning additional clothing on a cold day or seeking shaded areas during periods of heat—and involuntary, autonomic responses, including the constriction or dilation of peripheral blood vessels [12]. The thermoregulatory center within the hypothalamus consists of numerous neurons, referred to as thermoreceptors, which integrate information from peripheral temperature detectors in the skin and from central thermoreceptors that monitor core body temperature in internal organs and the spinal cord, thereby coordinating the activation of multiple regulatory mechanisms. In response to specific physiological demands, the body can either generate or dissipate heat, a process mediated not only by the brain—particularly the hypothalamus—but also by the skin, sweat glands, skeletal muscles, and additional systems, including the vascular, nervous, and endocrine systems [11].

In humans, two thermal units can be identified: the central compartment, which remains relatively stable, and the peripheral compartment, which varies according to location and is generally cooler than the central, acting as a transitional zone between the core body temperature and the external environment [12]. The interplay between these compartments serves as the basis for understanding hypothermia, defined as a reduction in temperature below 36˚C. Three degrees of severity can be distinguished: mild (36˚C–34˚C), moderate (34˚C–32˚C), and severe (<32˚C) [13]. Hypothermia results in numerous complications, including potential disruption of cardiac function, delayed termination of anesthetic effects, impaired convalescence and wound healing, shivering, coagulation disorders,all the aforementioned aspects may contribute to a prolonged duration of hospitalization, which consequently lead to undesirable socio-economic consequences. Both passive and active methods for preventing hypothermia are well established. Passive strategies include measures such as covering the patient's body and increasing the ambient room temperature, whereas active strategies involve the use of devices including electric mattresses and blankets, as well as warming intravenous fluids and gases administered to the patient [12,13].

According to the 2021 guidelines of the European Resuscitation Council and the European Society of Intensive Care Medicine, a core body temperature exceeding 37.7˚C is classified as fever [14]. This condition may be triggered by inflammatory processes, malignancies, or autoimmune responses, encompassing both infectious and non-infectious origins, which indirectly stimulate the thermoregulatory center via released mediators and raise the hypothalamic set point [4,11]. The primary causes of fever observed in hospital settings include sepsis, malignancies, ischemia, and reactions to administered medications. Fever arises from the activity of prostaglandin E2 (PGE2), which is produced through the synthesis of arachidonic acid (AA) from membrane phospholipids via phospholipase A2 (PLA2), followed by conversion through cyclooxygenases (COX) into prostaglandin H2 (PGH2). PGH2 is subsequently transformed by PGE synthase into PGE2, which acts on the thermoregulatory center in the hypothalamus [4]. As a result of these changes, core body temperature increases, directly leading to an elevation in metabolic activity and mobilization of the immune system, while also creating unfavorable conditions for bacterial growth and significantly inhibiting their proliferation [11].

It is essential to recognize that fever and hyperthermia are not synonymous. In fever, organ and system functions remain intact, and the hypothalamus actively regulates the elevation of core body temperature. In contrast, during hyperthermia, the rise in temperature surpasses the hypothalamus's regulatory capacity, leading to uncontrolled changes in body temperature, while the hypothalamic set point remains unaltered [4,11].

An elevation in core body temperature induces multiple metabolic changes, including increased heart rate, heightened oxygen demand, and an elevated respiratory rate [4]. To counteract these potentially harmful alterations, the body dissipates heat to the surrounding environment via conduction, convection, and radiation [3]. Activation of cholinergic fibers of the sympathetic nervous system leads to increased activity of the sweat glands and perspiration. This mode of heat dissipation accounts for approximately 22% of the total heat loss under normal conditions [11], and can reach up to 80% during periods of intense physical activity [3]. Conversely, suppression of sympathetic activity in the peripheral blood vessels of the skin results in increased cutaneous blood flow, thereby facilitating greater heat dissipation to the environment [3,11]. It is estimated that up to 95% of the heat generated by the human body is lost through the skin [12].

Monitoring of Body Temperature in Clinical Practice

There are several anatomical sites in the human body where core temperature can be measured; among which, the pulmonary artery is considered the most reliable. Due to greater accessibility and lower invasiveness, alternative measurement sites include the distal esophagus, the nasopharyngeal cavity, and the tympanic membrane [12,13]. Advanced non-invasive technologies, such as the zero-heat-flux (ZHF) and double-sensor (DS) methods, utilize single-use detectors affixed to the patient’s head. These systems are distinguished by their non-intrusive application and capability for continuous temperature monitoring. Nevertheless, the accuracy of these measurement techniques requires further validation, although both methods already show promise as alternatives for detecting unintended perioperative hypothermia [15]. Irrespective of the method applied, continuous monitoring of body temperature remains crucial, as hyperthermia or hypothermia in critically ill patients exerts a significant influence on subsequent therapeutic management and clinical prognosis [16].

Each of the methods described possesses distinct advantages and limitations, with their selection largely determined by availability and the preferences of the medical personnel. Consequently, the role of physicians and nurses as intermediaries between clinical outcomes and the procedures employed is crucial, as their knowledge, expertise, and professional approach are key determinants of effective clinical practice.The experience and dedication of healthcare professionals in preventing unintended perioperative hypothermia are commendable. Nevertheless, hospital practice demonstrates that current interventions remain insufficient. Comprehensive, in-depth research is therefore required to derive new insights, establish more effective management protocols, and integrate them into routine clinical behaviors[17].

Medical indications for targeted intervention in body temperature

The body temperature of a healthy individual remains relatively constant; despite minor physiological fluctuations, this state can be referred to as normothermia. In clinical practice, specific indications exist for therapeutic interventions aimed at modifying a patient’s body temperature, either by inducing hypothermia through targeted temperature management (TTM) or, less frequently, by applying therapeutic hyperthermia.

Therapeutic hypothermia, defined as the controlled reduction and maintenance of core body temperature within the range of 32–34 °C [18], has been established as a therapeutic approach in various clinical contexts.

It is employed primarily in patients following cardiac arrest, as a neuroprotective intervention and in the management of acute ischemic stroke within the adult population. Its primary objective is to reduce cerebral metabolic activity and to exert antioxidant, anti-apoptotic, and anti-inflammatory effects, as well as to lower intracranial pressure and consequently diminish cerebral edema [19, 20, 21]. Such outcomes can be achieved through various techniques, the characteristics of which will be discussed in subsequent sections of this study.

In the context of targeted temperature management applied for neuroprotective purposes following cardiac arrest, numerous studies have debated the relative benefits of therapeutic hypothermia versus normothermia [22, 23]. The first reports drawing attention to targeted temperature management emerged in 2002, and since then, a substantial body of scientific literature has been published examining this issue in greater depth, evaluating its efficacy, neurological outcomes, and patient survival rates [16]. However, it can still be stated that the studies conducted to date, on the application of targeted temperature management, remain limited and inconclusive. This may, among other factors, result from the absence of detailed guidelines regarding the timing of TTM initiation following its indication, the duration of therapy, the severity of the underlying condition, as well as the criteria for its use and potential contraindications [18]. Based on the published data, it can be clearly stated that both hypothermia and normothermia, in certain clinical justifications, are markedly more beneficial for patients than an elevation of body temperature above the normal range. The 2021 European Resuscitation Council (ERC) guidelines, updated on the basis of the 2020 CoSTR (Consensus on Science with Treatment Recommendations) study, recommend targeted temperature management in unconscious patients after return of spontaneous circulation (ROSC) following cardiac arrest. The guidelines advise maintaining a target body temperature of 32–36 °C for a minimum of 24 hours and avoiding fever (>37.7 °C) for 72 hours [14].

It is also important to emphasize that the implementation of targeted temperature management is associated with multiple challenges in clinical practice. A significant concern involves alterations in pharmacokinetics and pharmacodynamics, which may lead to the accumulation of medications, including anesthetic and sedative agents. Such circumstances require meticulous monitoring by medical personnel and continuous adjustment of administered drug dosages [23].

Therapeutic hyperthermia, defined as the deliberate maintenance of an elevated body temperature within the range of 39–42 °C for a specified period, is employed in oncology in combination with immunotherapy, radiotherapy (RT), chemotherapy (CHT), or chemoradiotherapy (CRT) [24, 25]. This intervention enhances the cytotoxic activity of natural killer (NK) cells, increases immune system responsiveness, and improves tumor perfusion and oxygenation, thereby sensitizing the tumor to radiation. It may even induce a conversion of "cold" tumors into "hot" ones, resulting in increased susceptibility to immunotherapy [24]. The effectiveness of the applied procedure may be influenced by several factors, including the type and location of the tumor, the duration of heating, and the method used to induce hyperthermia, as different techniques vary in their depth of tissue penetration. Moreover, the immune response may manifest as either activation or suppression of immune functions [26].Given the potential variability of the achievable physiological responses, it is essential to conduct further, more advanced research in parallel with the development of novel technologies [26]. Particular emphasis should be placed on the precise determination of thermal doses and the continuous monitoring of body temperature in study participants [25].

Methods and technologies for therapeutic temperature modulation

Numerous methods of deliberate modulation of human body temperature are currently known. Techniques aimed at lowering body temperature are classified according to their systemic or selective mode of action. Systemic hypothermia involves three distinct phases: induction, maintenance and controlled rewarming. This approach ensures uniform cooling of the entire body but may lead to complications, such as electrolyte imbalances, infections, shivering and even cardiac arrhythmias. Another classification distinguishes between external and internal cooling techniques. Surface methods include the application of ice packs, cooling blankets, or pads, whereas internal methods involve the infusion of cold fluids or the use of intravascular cooling catheters. The use of selective cooling techniques holds significant clinical importance, as it helps minimize the adverse effects associated with systemic hypothermia by exerting only minimal influence on non-cooled parts of the body [21, 27]. However, despite their higher efficiency during the initial cooling phase and in maintaining the target body temperature, invasive methods do not correlate with improved clinical outcomes, including increased patient survival rates [20].

The opposite category comprises methods and devices designed to elevate body temperature, which are applied, for instance, in clinical oncology. Tissue heating, depending on its extent, enhances perfusion, improves oxygenation, and increases the sensitivity of cancer cells to therapeutic interventions. However, the application of higher temperature ranges may induce cellular apoptosis and necrosis. Among the methods used for patient warming are electromagnetic, ultrasonic, perfusion-based, and conductive heating. The extent of their effect can be categorized into three levels: local, loco-regional, and whole-body techniques [28]. Electromagnetic methods utilize radiofrequency, microwave, infrared, and laser heating. Ultrasonic techniques operate through the application of acoustic energy, whereas perfusion-based heating functions, among other mechanisms, by circulating warmed fluids within the patient's body cavities. A common feature shared by all these methods is the controlled elevation of temperature in accordance with predetermined therapeutic goals, while ensuring patient safety [28].

The review of the presented approaches demonstrates the broad spectrum of established methods for modulating human body temperature, ranging from systemic cooling to targeted heating resulting in destruction of malignant cells. Both categories share key principles: the reliability of thermal dose control, continuous monitoring of core body temperature and the optimization of physical parameters through the application of engineering and physical sciences in medicine.

Ethical and social perspective: defining the boundary between technological intervention and human existence

Intensive care management is a multidisciplinary field that requires the use of advanced medical technologies as well as the expertise and specialized training of healthcare professionals. The prevalence of unintended hypothermia is also influenced by the level of staff awareness, systematic analysis of risk factors, and strict adherence to preventive guidelines [8]. However, the lack of standardization in clinical management protocols, resulting from inconsistencies in research findings, still necessitates further development in this area [23]. It is worth emphasizing that, in intensive care units, patients often exhibit a diminished capacity to make autonomous decisions. In such cases, medical paternalism becomes evident—a phenomenon which, in its traditional interpretation, may adversely affect the physician–patient relationship by neglecting the patient's autonomy, preferences, and emotional experience [29]. This does not imply that medical paternalism should be entirely abandoned, as it is often clinically justified; however, both scientific rationale and humanitarian considerations must be equally taken into account [29]. To ensure high-quality patient care, the decision-making process should also involve the patient's family, thereby minimizing the potential for conflict in therapeutic decisions [8].

Discussion

Body temperature management in postoperative care and intensive care units is a fundamental factor influencing both therapeutic efficacy and patient prognosis and remains a subject of ongoing debate in clinical practice. Variations in body temperature—whether hypothermia, hyperthermia, or fever—may serve both as indicators of clinical severity and as potential therapeutic targets. Recent scientific reports demonstrate a shift in a clinical perspective, reflecting a departure from rigid, universal recommendations toward the adoption of new strategies that emphasize more individualized approach. This trend arises from the recognition of the unique clinical condition of each patient, including comorbidities, age, time elapsed since symptom onset, and other clinically significant factors [16, 18].

Scientific studies addressing targeted temperature management in post-resuscitation care have established the initial framework for hospital practice. However, recent research and analyses have shifted focus toward the multidimensional outcomes of this intervention and the need for a more precise evaluation of patients eligibility for such therapy. Earlier scientific evidence, including meta-analyses and systematic reviews, supported the notion that maintaining body temperature within a specifically defined range exerts neuroprotective effects and reduces the risk of neurological complications. Nevertheless, more recent reports suggest that the achievement of such benefits depends on factors such as patient selection, timing of therapy initiation, and target temperature, and they do not demonstrate a statistically significant difference in overall treatment outcomes [30]. At present, maintaining a body temperature of 32°C to 36°C for at least 24 hours after the return of spontaneous circulation (ROSC) remains a recommended practice. Nonetheless, the therapeutic benefits are not uniform across all patient groups, and clinical decision-making should be tailored to the individual needs of each patient [30].

From a clinical perspective, published studies focusing on preoperative and postoperative patient care emphasize the importance of hypothermia prevention and its prompt management through active patient warming, both prior to and during surgery, as well as the control of ambient temperature in the patient's environment [12]. It has been demonstrated that preoperative warming for 10 to 30 minutes effectively reduces the risk of inadvertent postoperative hypothermia, helps maintain intraoperative normothermia, and may even facilitate the patient's postoperative recovery process [31]. Considering its straightforward implementation and low resource requirements, such a strategy may hold significant potential as a standard preventive measure within preoperative care.

When considering the general population of patients admitted to intensive care units, the clinical approach to fever should focus primarily on identifying its underlying etiology and exercising caution in the initiation of antipyretic therapy. Routine administration of antipyretic treatment solely for the purpose of temperature reduction is not recommended, as fever often represents an early indicator of infection that warrants thorough diagnostic evaluation and a deeper understanding of its physiological purpose and potential consequences. Under these conditions, the recommended approach involves the use of microbiological and imaging studies as indicated by the clinical presentation, while refraining from routine temperature reduction in all cases [9].

With regard to the quality of care, as well as patient safety and comfort, the standardization of continuous body temperature monitoring remains essential. The variability observed in the implementation of different phases of TTM—reflected in the rate of achieving target temperature, the tools employed, and the applied procedures—significantly affects the reproducibility of collected data and the ability to perform objective comparisons across studies [21, 32]. Therefore, it is necessary to standardize reliable methods of data collection, unify procedural algorithms, and enhance both the knowledge of medical personnel and the quality of medical documentation.

Ethical considerations related to interventions in human body temperature regulation should not be overlooked, as they constitute an integral component of clinical decision-making. Before undertaking such a significant intervention in a patient's clinical condition, the potential balance between benefits and risks must be carefully evaluated, since a theoretically justified neuroprotective effect may lose its value in the presence of a serious infection or other major complication. Furthermore, in the absence of clear evidence demonstrating the superiority of one thermoregulatory strategy over another, it is ethically appropriate to make therapeutic decisions in consultation with the patient—or, when this is not possible, with the patient's family—while taking into account their individual values and priorities [8]. Effective communication represents another crucial factor influencing the course of care in the intensive care unit. Patients and their relatives may experience various anxiety and depressive disorders, as well as post-traumatic stress disorder (PTSD). Open and honest communication within the framework of shared decision-making can enhance satisfaction and confidence in the option selection procedure. Moreover, it may facilitate long-term treatment planning and contribute to improved overall patient care [23, 33].

Modern high-technology medicine faces numerous sociocultural and economic challenges. Societal expectations regarding temperature management interventions in patients admitted to intensive care units or receiving postoperative care may be demanding and often pose a challenge to implementation in daily clinical practice. Society often perceives advanced procedures such as TTM as a definitive means of providing aid to patients, thereby placing high expectations on these interventions. Studies have shown that families frequently misinterpret the use of modern medical technologies as a sign of clinical improvement, recovery, and renewed hope for their relatives. Perceiving the mere presence of advanced technologies as evidence of effective therapy fosters an unrealistic image of medical interventions and contributes to inflated expectations regarding the capabilities of modern intensive care medicine. This societal view of technological tools reveals a distinct social dimension, in which advanced medical technologies become symbols of progress and efficacy, regardless of the actual outcomes of implemented procedures. Conversely, the visible absence of advanced medical devices or technologies is often misinterpreted by patients' families as a sign of therapeutic withdrawal, helplessness, or even impending death of the patient [33]. Such misperceptions can be mitigated through effective and transparent communication with both the patient and their relatives. The goal of efficient communication should be to clearly explain the purpose of the applied procedures, their potential unintended side effects, and known limitations, as a lack of understanding and misinterpretation may lead to feelings of helplessness and confusion [33]. For this reason, it is essential to actively educate society that the effectiveness of therapy is a multifactorial outcome and depends not only on the presence of technologically advanced procedures and medical instruments, but also on the appropriate selection of treatment and the individualized consideration of the patient's clinical condition, including the provision of comprehensive information regarding possible adverse effects and complications. For instance, within the context of targeted temperature management, it is pertinent to acknowledge the potential occurrence of complications such as coagulopathies, infectious processes, metabolic disturbances, and other adverse physiological effects [13, 21]. Consequently, societal expectations should be counterbalanced by constructive and transparent communication, accompanied by a rational and evidence-based appraisal of the patient's actual clinical condition and prognosis [33].

High-quality medical care depends on the consistent adherence to established standards, as well as on the knowledge and experience of the clinical team, rather than solely on the use of costly tools or procedures. The economic dimension of TTM represents a substantial burden on the healthcare system, as it entails expenses related to the acquisition of TTM devices, core body temperature monitoring equipment, and the employment of additional medical personnel. Conversely, the prevention of inadvertent fluctuations in a patient's core body temperature necessitates the procurement of specialized equipment for continuous thermal monitoring, the strategic allocation of medical personnel, and the potential expenditure associated with adjunctive procedures. These may include active warming interventions employing thermal blankets, electrically heated mattresses, or the administration of pre-warmed intravenous fluids [12]. These measures are essential for ensuring patient safety in clinical practice and are likewise justified from an economic perspective. However, the consequences of uncontrolled hypothermia also directly contribute to increased healthcare costs due to the need for additional medical interventions and the prolonged duration of hospitalization [12]. The variability in procedural methodologies and the lack of standardization in TTM also have significant implications for both the cost and overall effectiveness of therapy [34]. The heterogeneity of applied techniques and utilized equipment introduces considerable challenges in conducting reliable economic analyses of TTM. This issue pertains not only to disparities between individual clinical centers but also extends to broader, system-level evaluations. The ambiguity of existing positions contributes to substantial variation in the individual costs of patient management and in the availability of modern, advanced technologies across different medical centers. It is therefore pertinent to reiterate the importance of patient and family awareness, particularly their understanding of the material and economic limitations inherent to healthcare institutions, as well as the common misconception that the presence of advanced medical equipment necessarily equates to the provision of the highest quality of care for their relatives [33]. Such misinterpretation reinforces social pressure to employ advanced technologies, even in clinical situations where simpler and more cost-effective methods could yield comparable therapeutic outcomes. Therefore, a rational approach to the selection of costly targeted temperature management techniques should be guided by both the patient's clinical condition and the economic capacity of the healthcare institution. Consequently, effective TTM may serve a dual function—both as an integral component of evidence-based clinical care and as an economically justified investment aimed at reducing the incidence of complications, thereby enhancing therapeutic efficiency, shortening the duration of hospitalization, and ultimately decreasing overall healthcare costs.

The review of the discussed issues indicates that clinical decision-making should be guided by high-quality, evidence-based research. However, it is equally important to recognize that TTM remains a therapeutic option requiring careful consideration of implementation strategies and continuous monitoring of its quality and effectiveness. Furthermore, in postoperative care and intensive care units, the use of inexpensive, simple, and readily available methods to prevent temperature fluctuations—when correctly implemented by appropriately trained medical personnel—may yield substantial clinical benefits and improve patient outcomes without the necessity of employing high-cost technologies. Moreover, medical decision-making pertaining to interventions in human thermoregulation should encompass not only evidence-based scientific rationale but also ethical dimensions, including equity, justice, and the integrity of communication, as well as broader sociocultural and economic considerations such as public education, societal perspectives, and prognostic expectations.

Despite the analysis of numerous scientific reports, many critical issues remain unresolved. There is a pressing need for randomized controlled trials that precisely identify the patient populations most likely to benefit from TTM, clearly define inclusion and selection criteria, and systematically compare various temperature monitoring strategies as well as procedural approaches to thermal modulation. It is also necessary to consider a comprehensive cost-effectiveness analysis in relation to the expected therapeutic outcomes under real-world clinical conditions. Such an approach would help to mitigate the heterogeneity observed in current strategies concerning the selection of targeted temperature management methods, the timing of induction, and the determination of target temperature ranges [22].

Conclusions

Despite the extensive body of knowledge and the technological advancements that enable both the continuous monitoring and precise modulation of human body temperature, this field still necessitates high-quality, systematic randomized controlled trials to further elucidate the underlying mechanisms and to identify the causes of the inconsistencies observed in previous research findings. It is important to emphasize the critical role of medical personnel in the therapeutic decision-making process, particularly in the care of patients with limited capacity to provide informed consent, as well as the significance of fostering effective collaboration and communication between healthcare providers, the patient, and the patient's family. Temperature management in postoperative care, as well as in the routine management of patients in intensive care units, represents a critical determinant of patient prognosis. It requires a personalized approach supported by clearly defined and standardized inclusion and exclusion criteria grounded in robust scientific evidence, while simultaneously accounting for the ethical, economic, and social dimensions inherent to clinical practice. A key aspect should involve the implementation of simple preventive interventions, such as continuous monitoring of core body temperature, complemented by the selective use of more costly targeted temperature management technologies. This approach would enable the rational utilization of available resources while maximizing therapeutic outcomes.

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