

Remote temperature monitoring in clinical practice: SteadyTemp and TempTraq

Tomasz Fajferek, Jędrzej Mikolajczyk, Aleksander Joniec, Seweryn Kaczara, Emma Mażul Kulesza, Barbara Pietrzyk

Department of Medical Biophysics, Faculty of Medical Sciences in Katowice, Medical University of Silesia in Katowice, Poland

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Abstract

Body temperature is a key vital sign, but traditional intermittent monitoring in hospitals increases nursing workload. Continuous monitoring via wearable sensors could improve efficiency and early deterioration detection, but systematic evidence remains scarce. This study therefore aimed to evaluate the clinical application of the SteadyTemp® and TempTraq® wireless temperature sensors for integration into clinical care protocols. A narrative review of the literature (PubMed/Embase, 2020–2025) including 58 clinical studies was conducted. The systems were compared in terms of accuracy, battery life, patient comfort, data security, and integration with hospital information systems/electronic medical records. Statistical analysis included means, standard deviations, and trend analysis. Both systems demonstrated clinical utility but differed in application. SteadyTemp® offers stable 7-day monitoring and GDPR-compliant data integration, suiting hospital use. TempTraq® provides high real-time accuracy (measurements every 10 s), benefiting paediatrics, but has a shorter 72-hour lifespan and higher cost. Wireless sensors are a valuable complement to traditional methods, enabling continuous, automated monitoring. SteadyTemp® is optimal for hospital settings, while TempTraq® is ideal for short-term paediatric fever detection, improving workflow and supporting early infection detection.

Introduction

Body temperature is one of the fundamental vital signs in humans, with a normal physiological value averaging approximately 36.6°C (range: 36.1–37.2°C). This value is relative and subject to physiological fluctuations. The principal centre responsible for thermoregulation is located in the hypothalamus [1]. Numerous factors influence temperature homeostasis, including age, sex, the presence of disease or injury, vascular tone regulation, sweating, and the sleep–wake cycle [2]. Hyperthermia is most commonly defined as a body temperature of $\geq 38^{\circ}\text{C}$. The most frequent cause of elevated body temperature is an increased production of pyrogens, of which interleukin-6 (IL-6) is the key representative. Enhanced pyrogen synthesis typically arises as a consequence of immune responses or tissue injury. Pyrogens stimulate cyclooxygenase-2 (COX-2), leading to the production of prostaglandins. Prostaglandin E2 (PGE2) is recognised as the principal central mediator of fever, raising the hypothalamic set point for physiological body temperature [3]. In hospitals, routine measurement of body temperature is carried out primarily by nurses, most commonly using electronic thermometers. Despite increasing automation, these procedures

consume time that could otherwise be devoted to enhancing the quality of patient care [4].

Fever, although often perceived as a nonspecific symptom, holds significant diagnostic value across a wide range of clinical conditions. In infectious diseases, persistent elevation of body temperature may serve as an early marker of sepsis, necessitating rapid medical intervention and guiding the initiation of antimicrobial therapy [5]. In oncology, fever of unknown origin may indicate neutropaenic complications or tumour-related processes, while in autoimmune disorders it frequently accompanies systemic inflammation [6]. Continuous monitoring of body temperature thus provides clinicians with a valuable tool for early differentiation of disease states and assessment of treatment response [7].

An innovative approach to automated body temperature measurement involves the use of wearable technologies, specifically adhesive patches that enable continuous, non-invasive monitoring [8]. Examples include the SteadyTemp® and TempTraq® systems, which allow for periodic measurements and data analysis through synchronisation of the patch's temperature sensor with a mobile application [4]. SteadyTemp® is a clinical surface thermometer designed for continuous, non-invasive body temperature monitoring in

medical settings. The system consists of a non-sterile adhesive patch with an NFC-activated sensor and the dedicated Android-based SteadyTemp Monitor mobile application. Temperature is measured once every minute, with data transmitted to the application, processed, and displayed as graphs, thereby enabling real-time monitoring of patient temperature trends [4]. The patches, certified to IPX5 (protection against low-pressure water jets from any direction), are equipped with temperature sensors and manufactured from certified insulating materials that minimise the influence of external factors, thereby ensuring measurement reliability. In response to the growing demand for patient monitoring, modern technologies such as wireless temperature sensors (e.g. SteadyTemp®, TempTraq®) provide tangible support for healthcare professionals. Through continuous and precise temperature measurement, and integration with hospital information systems (HIS) via HL7/FHIR standards, these solutions have the potential to enhance the quality of care, improve workflow efficiency, and contribute to better clinical outcomes [4].

Looking ahead, the integration of wearable thermometry with advanced data analytics and artificial intelligence (AI) offers new opportunities for precision medicine [9]. Machine learning algorithms can detect subtle patterns and deviations in temperature dynamics, potentially predicting infection onset or disease exacerbation before clinical symptoms become evident [10]. When combined with other biosignals, such as heart rate or oxygen saturation, temperature data may form part of a broader digital biomarker framework, enabling proactive and personalised healthcare [11]. Such developments not only enhance patient safety but also support the paradigm shift towards predictive and preventive.

The adoption of continuous temperature monitoring technologies offers benefits not only at the system level but also from the patient's perspective [12]. For healthcare providers, automation of routine measurements reduces the burden on medical staff and supports more efficient allocation of resources, which in turn may lower overall healthcare costs [13]. At the same time, patients gain from enhanced comfort, as wearable devices minimise the need for repeated manual assessments and provide a sense of safety through uninterrupted surveillance [14]. This dual advantage – improving workflow efficiency while simultaneously increasing patient well-being – highlights the potential of wearable thermometry to become an integral component of modern, patient-centred healthcare.

Methods

A narrative literature review was conducted using two leading biomedical databases, PubMed and Embase, accessed through university resources. The aim

of the search was to identify clinical studies evaluating the use of wireless sensors for body temperature measurement in patients. The following devices have been awarded FDA accreditation: K233280 for SteadyTemp and K143267 for TempTraq. Keyword combinations were applied, including both technology-specific terms and manufacturer names (e.g. SteadyTemp, TempTraq), as well as broader terms such as “wireless body temperature monitoring”, “wearable technology”, “wearable device”, “clinical trial”; specific: “SteadyTemp”, “TempTraq”, “adhesive patch”, “axillary thermometer”, “continuous temperature measurement”. The search was restricted to publications from January 2020 to September 2025 (5 years), including studies with at least 15 patients, available in full text, written in English, and designed as clinical trials (excluding case reports, technical notes, and narrative reviews). The identified publications underwent preliminary screening based on titles and abstracts, followed by full-text assessment for eligibility. Data extraction focused on the type of sensor used, patient population, clinical setting, measurement methodology, and the main outcomes related to the effectiveness and usability of surface temperature monitoring systems.

As part of the review, temperature monitoring systems such as SteadyTemp® and TempTraq® were compared with respect to their technological specifications, clinical applications, compliance with data protection regulations (GDPR), operating time, and potential for integration with health information systems. The analysis was based on data from the scientific literature as well as technical information provided by the manufacturers. Devices were evaluated according to their intended use, method of application, monitoring frequency and duration, compliance with data protection standards (server location, GDPR compliance), and interoperability with HIS/EMR systems (via API/HL7/FHIR) [15].

The present study encompasses clinical studies evaluating wireless temperature sensors (including SteadyTemp/TempTraq or related technologies) reporting at least one of the following outcome categories: measurement accuracy, reading frequency, sensor operating time, comfort/usability, integration with HIS/EMR systems, and data security.

The following criteria determined the exclusion of studies from our review: works that present the full text in languages other than English; case reports; studies that are purely technical in nature and which do not include clinical data; narrative reviews; conference abstracts and other not fully published text-articles (Figure 1).

Methodology of comparative analysis

The analysis included clinical studies on wireless temperature monitoring, evaluating parameters such as measurement accuracy, reading frequency, sensor op-

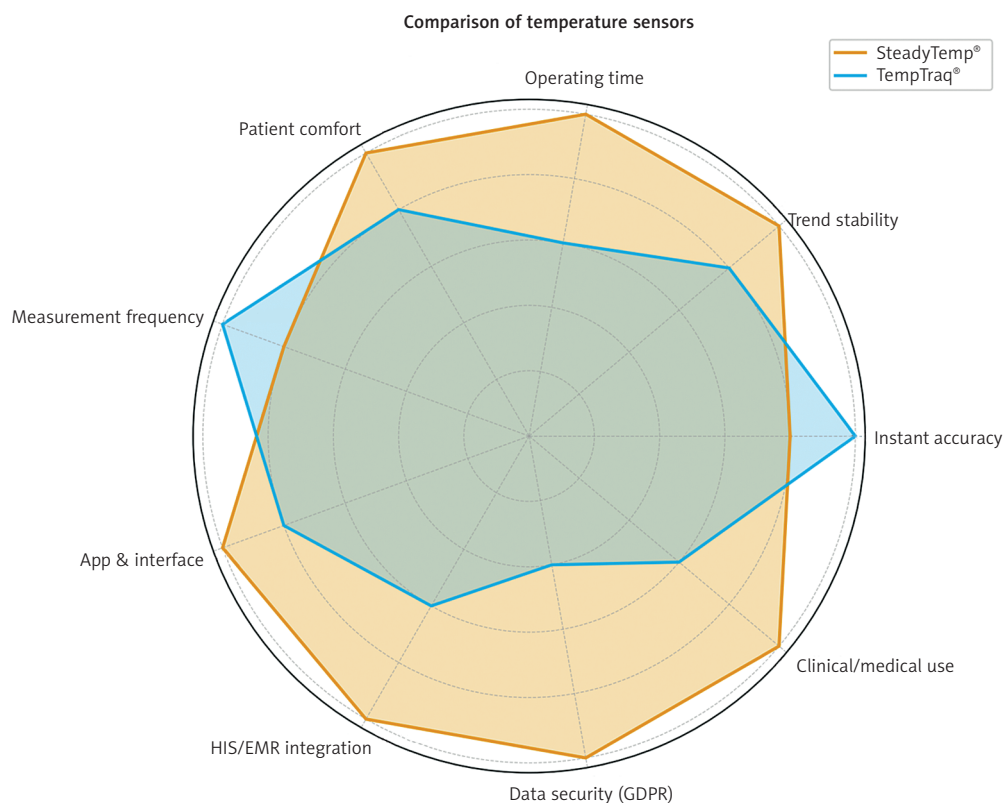


Figure 1. Comparison of selected body temperature sensors (multi-criteria analysis)

erating time, integration capabilities with medical systems, wearing comfort, and application functionality.

The SteadyTemp® and TempTraq® systems were compared in terms of accuracy, operating time, patient comfort, data security, and integration with Hospital Information Systems (HIS)/Electronic Medical Records (EMR) compliant with the General Data Protection Regulation (GDPR) [16].

Data were subjected to narrative analysis regarding measurement accuracy and temperature trend stability (based on standard deviations and regression analysis), measurement frequency and sensor operating time (distribution analysis and mean values), user comfort (based on visual analogue scales [VAS] used in patient studies), GDPR compliance and data security (assessment of system compliance with legal requirements, evaluated binarily: compliant/non-compliant), and integration with HIS (qualitative and quantitative assessment) [17].

Comparative data were compiled in Microsoft Excel and subsequently presented graphically as tables and a radar chart (spider chart), facilitating visual assessment of key functional differences between devices and enabling rapid identification of the strengths and weaknesses of the temperature sensors. Comparisons between systems were performed using graphical data presentation, allowing functional differences and their clinical relevance to be readily discerned.

Results

A literature review was conducted in the PubMed and Embase databases (covering 2020–2025), focusing on clinical studies evaluating temperature monitoring systems. Both qualitative and quantitative data were analysed, including technical specifications, measurement accuracy, sensor operating time, data security, patient comfort, and integration capabilities with health information systems (HIS/EMR). Based on the collected data, comparative tables were created to analyse selected criteria for both systems (SteadyTemp® and TempTraq®).

Analyses were performed on measurement accuracy and temperature trend stability (based on standard deviations and regression analysis), measurement frequency and sensor operating time (distribution analysis and mean values), user comfort (assessed using visual analogue scales [VAS] from patient studies), GDPR compliance and data security (evaluated binarily: compliant/non-compliant), and HIS integration capabilities (qualitative and quantitative assessment – number of available APIs and system architecture openness). Results were also presented as a radar chart, enabling rapid multidimensional comparison of the two systems.

The summary table additionally includes overall scores for each criterion with corresponding justifi-

Table 1. Comparison of selected body temperature sensors (multi-criteria analysis)

Criterion	SteadyTemp®	TempTraq®
Measurement accuracy	Good ($\pm 0.2^{\circ}\text{C}$), optimised for trends	Very good ($\pm 0.1^{\circ}\text{C}$), fast response
Measurement of sudden changes	Extended measurement time	Faster momentary reading, useful for children's fevers
Trend stability	High – correction algorithms	Good – for detecting fever
Trend precision	Simplified temperature diagram	Better representation of the temperature course over time
Sensor operating time	Up to 7 days (one-time)	Up to 72 h (disposable)
Reusable	No	No
Patient comfort	Very good – thin, light	Good – flexible, paediatric design
Measurement frequency	Every minute	Every 10 s, transfer every few minutes
App and interface	Professional, for medical staff	Simple, for caregivers
Integration with HIS/EMR systems	Yes – API, integration possible	Limited
Data security (GDPR)	GDPR compliant, EU servers	Possible servers in the USA – GDPR risk
Clinical/medical use	Yes – use in hospital	Limited – mainly domestic

cation, indicating the predominant system in each category. SteadyTemp® and TempTraq® were selected for comparison due to their use in continuous, non-invasive body temperature monitoring. A comparative analysis of these wireless temperature monitoring systems demonstrated significant differences in technical specifications, clinical applications, system integration, and compliance with data protection regulations. Detailed comparisons are presented in Table 1. SteadyTemp® is a system designed for hospital use and is applied exclusively by healthcare personnel. It enables continuous temperature monitoring for up to 7 days, integrates with HIS/EMR systems via API, and stores data on EU-based servers in compliance with GDPR. The device supports infection control and improves care efficiency [15]. SteadyTemp® demonstrates high stability in temperature trend measurements (based on surface temperature correction using advanced algorithms), making it suitable for long-term patient monitoring in hospital settings. The sensor allows continuous measurements every minute for up to 7 days without replacement, making it appropriate for patients requiring ongoing vital sign monitoring (Table 1). Additionally, the system offers an open architecture, enabling integration with HIS/EMR systems via API, and ensures full GDPR compliance by storing data exclusively on servers located within the European Union [15]. In contrast, TempTraq® is a single-use patch intended for both hospital and home use, particularly in paediatrics. It allows rapid temperature measurement for up to 3 days. The device is easy to use but incurs higher daily costs. Data are stored outside the EU, posing a potential regulatory hurdle under General Data Protection Regulation

(GDPR). TempTraq® is recommended for short-term fever monitoring [18].

TempTraq® demonstrates high instantaneous accuracy ($\pm 0.1^{\circ}\text{C}$) with readings every 10 s, which is particularly valuable for the rapid detection of sudden temperature elevations, especially in children and in home care settings. Its limitations include the short operating time (up to 72 hours), lack of integration with medical systems, and data storage outside the EU (Table 1) [15].

Both systems are comfortable – SteadyTemp® owing to its lightweight design(4), and TempTraq® due to its flexibility for children [19]. Only SteadyTemp® provides applications for medical staff that enable trend monitoring and real-time data analysis, thereby supporting a personalised approach to monitoring high-risk patients. From a data security perspective, SteadyTemp® holds a clear advantage – data are stored on servers within the EU, in compliance with the GDPR. In contrast, for TempTraq®, the possibility of data transfer outside the EEA (to the USA) represents a potential regulatory risk (Table 1) [15].

SteadyTemp® demonstrates advantages in trend stability, extended operating time, and integration with hospital information systems (HIS/EMR), whereas TempTraq® is characterised by higher instantaneous accuracy and greater measurement frequency. Both sensors ensure a high level of patient comfort but differ in their intended use – clinical (SteadyTemp®) versus home-based (TempTraq®) [4]. The analysis suggests that the technologies are complementary, with SteadyTemp® being better suited to hospital monitoring requirements and TempTraq® better for home care. SteadyTemp® was developed for hospital use, provid-

ing integration with clinical infrastructure, regulatory compliance, and the possibility of long-term monitoring. In contrast, TempTraq® is most applicable in paediatrics and ambulatory settings, where short-term, rapid detection of temperature changes is essential. In clinical practice, SteadyTemp® offers a more stable and integrated solution that complies with European data security standards, whereas TempTraq® serves as a complementary tool, particularly for sudden temperature elevations in children [19].

Discussion

The introduction of wireless temperature sensors into routine clinical practice opens new possibilities for continuous and non-invasive monitoring of hospitalised patients, particularly outside intensive care units. These solutions provide an opportunity to automate the surveillance of vital signs and enable early detection of pathological conditions. This paper focuses on the comparison and evaluation of so-called wearable technologies, specifically adhesive patches for monitoring skin temperature, with respect to their clinical utility, technological functionality, and potential for integration into current hospital care standards.

The evaluation of the SteadyTemp® system, based on the study by Boyer *et al.*, allows assessment of both its effectiveness and potential limitations in the context of continuous skin-based temperature measurement [4]. SteadyTemp® records data every 5 minutes, enabling the creation of dynamic, real-time patient temperature profiles. This monitoring approach facilitates early detection of febrile episodes and identification of subtle circadian rhythm variations, both of which are of considerable importance in the diagnosis of infections and thermoregulatory disorders. The system demonstrates particular value in high-risk populations, including oncology patients. Its greatest strength lies not in absolute precision, but in the ability to track individual temperature trends, thereby supporting a more personalised approach to patient health monitoring [4]. Among the limitations, susceptibility to external environmental factors and a delayed response to changes in core temperature should be noted, in contrast to the TempTrack® system. Nevertheless, the ability to automatically synchronise with electronic medical record systems makes SteadyTemp® an attractive tool for supporting clinical workflows [4, 17]. Lou *et al.* demonstrated that skin temperature monitoring has both diagnostic and prognostic value in wound healing, with elevated temperature after the third postoperative day potentially indicating infection. The FWHS (Flexible Wound Healing Sensor), based on a flexible patch incorporating the STH21 (Temperature Sensor Humidity 21) and a mobile application, enables precise real-time temperature measurement, highlighting

the potential of wireless solutions for monitoring not only fever but also the healing of surgical and chronic wounds [20]. Tang *et al.* emphasised the growing role of wearable technologies in monitoring inflammatory biomarkers and wound healing, in line with the recommendations of the World Union of Wound Healing Societies (WUWHS) [21], thereby extending diagnostics beyond the boundaries of traditional hospitalisation. Flexible temperature sensors integrated into smart dressings enable continuous, non-invasive real-time monitoring of the wound microenvironment.

Despite the rapid development of this technology, there remains a need to increase sensor sensitivity, refine interpretative algorithms, and ensure long-term stability of readings to enable effective clinical application [22]. Yang *et al.* proposed an innovative combination of electroactive therapy with simultaneous wound temperature monitoring. The Ag/Zn@PLA dressing developed by the researchers, based on silver and zinc electrodes and a DHT11 (Digital Humidity and Temperature sensor 11), not only records thermal data but also actively promotes healing through electrical stimulation and antibacterial effects [23]. Owing to its anti-inflammatory properties and ability to promote angiogenesis, this system provides both diagnostic and therapeutic functions [4]. Although research is still at the preclinical stage, it highlights the potential development of future “smart” dressings capable of dynamically responding to changing pathological conditions. Furthermore, a retrospective study by Liou *et al.* demonstrated that skin temperature alone can serve as a non-invasive indicator of tissue perfusion in patients with diabetic foot ulcers (DFU) [22]. Observing temperature differences between the wound centre and the surrounding tissue allowed for assessment of therapy effectiveness and healing progression. The results suggest that regular skin temperature monitoring may serve as an objective tool for evaluating prognosis and the early detection of microcirculatory disturbances. Integrating such measurements with wireless monitoring systems could significantly enhance patient surveillance in both hospital and outpatient settings [24]. Another system, inflammation-monitoring-treatment (IMT), introduced by Liu *et al.*, integrates highly sensitive amorphous silicon-based temperature sensors with local treatment capabilities. The use of a sensor array enables the creation of inflammation maps with submillimetre resolution and the initiation of targeted therapy, in this case, controlled antibiotic release triggered by a 780-nm infrared light source (1 mm). The system operates in a closed loop, combining diagnostics with treatment, representing a unique approach to managing skin and wound infections. Supported by wireless data transmission, this technology holds significant potential for clinical application [24].

Kim *et al.* evaluated a smart patch for continuous skin temperature monitoring, demonstrating a high

agreement with readings from a forehead thermometer (94%). Although the device showed lower sensitivity in detecting sudden fever spikes, it provided greater measurement stability by eliminating user errors and being resilient to changes in body position. The ability to transmit data to cloud-based platforms in real time enables remote monitoring, which is particularly relevant in the context of infectious isolation and home care. Due to their patient tolerance, such patches could become a valuable complement to conventional temperature measurement methods [8]. Furthermore, Yoon *et al.* presented an advanced, multifunctional hybrid patch integrating a flexible temperature sensor directly onto the substrate surface.

The sensor exhibited high sensitivity (2470 ppm/°C, i.e. the output signal changes by 0.247% per 1°C increase), excellent linearity ($R^2 = 0.997$, meaning the sensor signal changes almost perfectly proportionally to temperature with minimal deviation from linearity), and outstanding repeatability (RSD = 0.01%) [25]. Under testing conditions, the device maintained measurement accuracy even in the presence of sweat, during movement, and under bending – critical factors for clinical use in mobile patients. The ability to integrate temperature monitoring with pH, ECG, and glucose measurements enhances the potential for comprehensive patient monitoring without increasing staff workload or patient discomfort [25].

The PETAL system, developed by Zheng *et al.*, represents an innovative approach to wound monitoring, featuring a battery-free design, artificial intelligence, and colorimetric technology. Five integrated sensors allow simultaneous tracking of parameters such as temperature, pH, trimethylamine, uric acid, and moisture. Analysis of images captured with a smartphone camera using neural networks enables the assessment of wound healing status with very high accuracy (97%). The PETAL (Portable Evaluation of Tissue and Lesions) system offers a relatively low-cost, non-invasive, and competitive diagnostic alternative, with potential applications in both outpatient care and home-based monitoring [26].

In recent years, there has been rapid development of smart body temperature monitoring systems in the form of so-called smart patches. These devices, in addition to continuous and remote measurement of physiological parameters, increasingly combine diagnostic and therapeutic functions, supporting wound healing and preventing infectious complications. Particularly intensive research in this field is being conducted in Asian countries [27], where the fast pace of technological advancement facilitates the implementation of solutions integrating bioelectronics, nanomaterials, and personalised medicine [28]. In the context of solutions such as SteadyTemp® and TempTraQ®, the development of smart patches points toward a future clinical practice in which remote body

temperature monitoring will serve not only as a diagnostic tool but also as an element of active therapy.

The authors' review of wireless temperature monitoring and advanced multiparametric systems underscores the rapid evolution of this field at the intersection of medicine and modern technology. The integration of temperature sensors with real-time data analysis, remote monitoring, and targeted therapy could help establish a new standard of clinical practice, in which personalised care, automation, and early detection of physiological changes are key components of effective treatment.

Conclusions

Wireless temperature sensors, such as SteadyTemp® and TempTraQ®, provide a valuable complement to traditional patient monitoring by enabling continuous, non-invasive measurement with minimal staff involvement. The greatest clinical benefit lies in the ability to record individual thermoregulatory patterns, facilitating early detection of pathological fever and infections. Skin sensor technology can also assess tissue perfusion and detect inflammation, and support wound healing. The development of smart patches, integrating diagnostic and therapeutic functions, points toward a future of personalised, technology-driven clinical care.

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Ethical approval

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Conflict of interest

The authors declare no conflict of interest.

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Address for correspondence

Jedrzej Mikolajczyk

Department of Medical Biophysics

Faculty of Medical Sciences

Medical University of Silesia

Katowice, Poland

E-mail: jedrzejmikolajczyk@interia.pl

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