The Economic Impact of Time-to-Target-Temperature of Different Surface Cooling Technologies for Temperature Management in Critically Ill Patients: A Systematic Review, Analysis, and Model

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Background

Active temperature management at decreased temperatures has been an important, evidence-based component of adult post-cardiac arrest care for two decades.[1] The process of cooling patients may be achieved via different techniques including surface cooling.[2] Of these systems, conventional water-circulating cooling blanket (CCB) systems may be ineffective as a means of conductive heat transfer because they make poor surface contact with the skin.[3] External cooling devices have been developed that employ self-adhesive, hydrogel-coated pads that circulate temperature-controlled water under negative pressure.[3] These advanced targeted temperature management (ATTM) devices have been found to be substantially more effective for reducing fever burden in critically ill neurologic patients.[3] In cardiac arrest patients, ATTM devices with gel-adhesive pads have been found to provide more effective temperature maintenance[4] and lower proportion of patients with poor neurologic outcomes[5] than do traditional surface cooling devices. Temperature variability and thrombocytopenia were significantly less in neonatal patients treated with gel pad-based ATTM systems compared to patients treated with conventional cooling blankets.[6]

Elevated temperature has been associated with cost-of-care consequences adding 3.2 additional intensive care unit (ICU) days in neurocritical care patients.[7] In out-of-hospital cardiac arrest survivors, therapeutic hypothermia (target temperature 33°C) reduced ICU length of stay (LOS).[8] That same study did not calculate ICU treatment costs although the authors speculated that such an analysis might be an additional argument for therapy.[8]

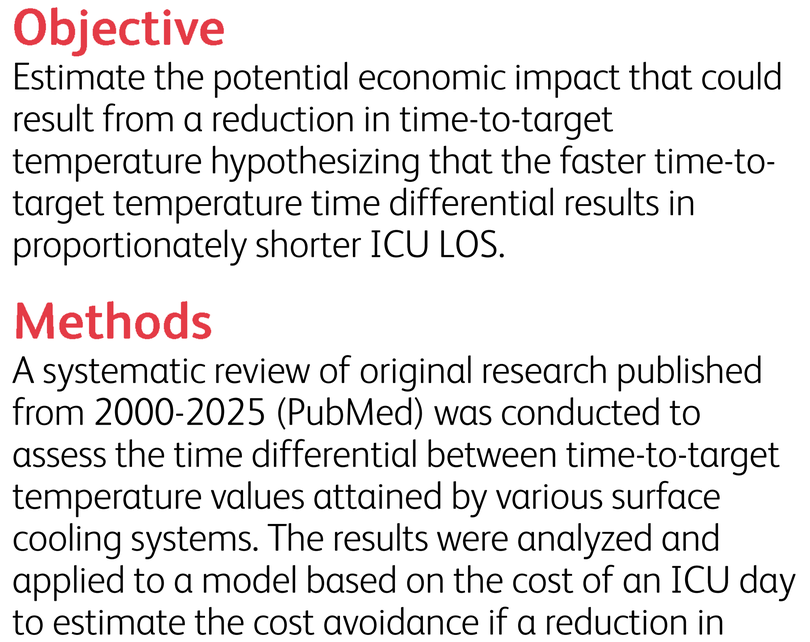
Objective

Estimate the potential economic impact that could result from a reduction in time-to-target temperature hypothesizing that the faster time-to-target temperature time differential results in proportionately shorter ICU LOS.

Methods

A systematic review of original research published from 2000-2025 (PubMed) was conducted to assess the time differential between time-to-target temperature values attained by various surface cooling systems. The results were analyzed and applied to a model based on the cost of an ICU day to estimate the cost avoidance if a reduction in time-to-target temperature subsequently reduced ICU LOS.

Figure 1: PRISMA Diagram



Search String: ("time to target temperature" OR "time to temperature" OR "time to goal temperature" OR "time to target") AND ("surface cooling" OR "water blanket" OR "Gel Pad" OR "cooling blanket")

Database: PubMed Search Date: 10/07/2025

PRISMA: Preferred Reporting System for Systematic Reviews and Meta-Analyses

Table 1: Publication Analysis

First Author	Publication Year	Type of Patient	N	Comparison Devices	Time to Target Temperature: Gel Pad -Based ATTM	Time to Target Temperature: CCB System	Time to Target Temperature: Difference (hours)
Heard[5]	2010	Out-of-hospital cardiac arrest patients	64	Conductive gel surface cooling[a] vs. one of two types of standard cooling blankets[b]	3.17	4.07	0.90
Jung[9]	2018	Out-of-hospital cardiac arrest patients	53	Gel pad cooling device[a] vs. standard water blanket[c]	2.24	3.89	1.65
Sonder[4]	2018	Out-of-hospital and in-hospital cardiac arrest patients	72	Gel-coated adhesive cooling pads[a] vs. water-circulating cooling blanket Type 1[d]	3.02*	3.69*	0.67
				Gel-coated adhesive cooling pads[a] vs. water-circulating cooling blanket Type 2[e]	3.02*	7.38*	4.36
Aujla[10]	2017	Neurocritical care patients with elevated temperature	21	Advanced hydrogel wrap[a] vs. standard cooling wrap[f]	2.22	16	13.78
						Mean time differential:	**4.27**

[a]Arctic Sun System [b]No further descriptions of the standard devices were provided [c]Cincinnati Sub-Zero Blanketrol II
[d]Blanketrol II & III, Gentherm/Cincinnati Sub Zero [e]Medi-Therm II and III, Stryker/Gaymar [f]Gaymar Medi-Therm Hyper/Hypothermia System
*Cooling rates reported: 1.49, 1.22 and 0.61 °C/hr for Arctic Sun, Blanketrol and Medi-Therm, respectively. Time calculated as time to move 4.5°C (from 37.5°C to 33°C).

Table 2: Cost Avoidance Model

	Improvement in Time-to-Target Temperature (hours)	Cost per ICU Day	Projected Cost Avoidance
Min	0.67	$6,391[11,g]	$178
Max	13.78	$11,304[13]	$6,490
Mean	**4.27**	**$8,858**	**$1,576**

[g]Halpern value of $4,300 in 2010 dollars adjusted to 2025 dollars with the U.S. Bureau of Labor Statistics CPI Inflation Calculator. https://www.bls.gov/data/inflation_calculator.htm. Accessed October 7, 2025.

[h]Dasta et al. reported ICU cost of $19,725 for a 4-day stay yielding an average cost of $4,931/day

[i]Dasta value of $4,931 in 2002 dollars adjusted to 2025 dollars with the U.S. Bureau of Labor Statistics CPI Inflation Calculator. https://www.bls.gov/data/inflation_calculator.htm. Accessed October 7, 2025.

Results

21 records were identified. After exclusions, 17 records were reviewed and 4 were analyzed (Figure 1). Gel pad-based ATTM systems were reported to have a faster time-to-target temperature compared to CCB systems across all analyzed studies with a mean time differential of 4.27 (range: 0.67 to 13.78 hours) (Table 1).

Three values for the cost of an ICU day were found in the literature ($6,391[11,g]; $8,880[12,h,i]; $11,304[13]) yielding a mean value of $8,858 per day (Table 2).

The estimated cost avoidance attained with a gel pad-based ATTM system, assuming that a reduction in time-to-target temperature subsequently reduced ICU LOS, was attained by multiplying the mean difference in time-to-target temperature in hours (then divided by 24 hours/day) by the mean cost of an ICU day yielding a projected cost avoidance of $1,576 (Table 2). The range of potential cost avoidance ($178 to $6,490) was found by multiplying the minimum and maximum values for time differential and cost per ICU day, respectively.

Limitations

There was a degree of heterogeneity in the studies analyzed potentially limiting the generalizability of results. Importantly, time-to-target temperature was assumed to proportionately extend ICU LOS, and while elevated body temperature has been associated with substantially longer ICU and total hospital LOS in patients with stroke and neurologic injury,[14] the impact of speed of temperature control upon ICU LOS remains unstudied.

Discussion

LOS, including execution by the minute, is a critical metric for the financial performance of both hospitals and health systems.[15,16] Gel pad-based ATTM systems have been found to reach goal temperature quickly and maintain TTM goals with a high level of accuracy in critically ill pediatric,[17] neurocritical care,[10] and cardiac arrest patients.[4,5,9] This review and analysis found that these gel pad-based ATTM systems achieve faster time-to-target temperature than do CCB systems, however, prospective studies should validate whether that time improvement translates to shorter ICU LOS.

Conclusions

Gel pad-based ATTM systems may avoid substantial ICU costs compared to CCB systems if reductions in time-to-target-temperature result in equivalent reductions in ICU LOS. This model estimated an avoided cost of $1,576 in patients managed with gel pad-based ATTM systems.

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