International Journal of General Practice Nursing, 2025, Volume 3, Issue 4
https://ojs.bbwpublisher.com/index.php/IJGPN
ISSN Online: 2981-9423
ISSN Print: 2981-9415

Practice and Effectiveness Analysis of Electricity Conservation in Pediatric Wards Based on a Multi-Dimensional Collaborative Intervention Strategy

Ruizhi Huang, Qiuqing Jin, Jialin Ye*

Nansha Division of the First Affiliated Hospital, Sun Yat-sen University, Guangzhou 511466, Guangdong, China

**Author to whom correspondence should be addressed.*

Abstract: As high-energy-consuming public buildings and medical institutions, hospitals hold profound significance for the realization of China's "dual carbon" goals through their energy management. Taking pediatric wards as the research object, this study constructed a three-dimensional collaborative intervention model of "institutional level—equipment level—behavioral level" targeting their energy consumption characteristics (dense wards, high accompanying rate, and continuous operation of medical equipment). Through a stepped controlled trial design (self-control during 2024—2025 and spatial control with gynecological wards), this study systematically evaluated the implementation effect of energy-saving measures. The research results show that after the implementation of intervention measures, the monthly average electricity savings in pediatric wards exceeded 900 kWh, with an average electricity saving rate of 21.36%. Through difference analysis, the impact of external environments was excluded, verifying the effectiveness of the three-dimensional collaborative mechanism. This study provides a comprehensive "technology-management-behavior" energy-saving path for medical institutions, which has high promotion value.

Keywords: Hospital energy conservation; Pediatric wards; Three-dimensional collaborative intervention model; Dual carbon goals

Online publication: December 17, 2025

1. Introduction

At the 75th Session of the United Nations General Assembly, China formally announced that it will strive to peak carbon emissions before 2030 and make every effort to achieve carbon neutrality before 2060, establishing the national-level "dual carbon" strategic goals. As a typical representative of energy-intensive buildings, hospitals have much higher energy consumption per unit area than ordinary commercial buildings [1–2]. Globally, hospitals account for approximately 5.2% of total carbon emissions, making them an unignorable carbon source [3]. Therefore, the effective implementation of energy management and carbon emission reduction in hospitals is directly related to the progress of achieving China's national "dual carbon" goals.

With the continuous rise in energy demand in the medical industry, hospital energy management (especially the power system) has emerged as a core issue in the logistics support system. In addition to reducing operational costs, energy management can improve air quality, enhance patient comfort, boost public trust and competitiveness, forming a "health-environment" win-win situation [4]. Relevant studies have shown that the air conditioning systems, lighting equipment, and office equipment in hospitals collectively consume more than 60% of the total electrical resources of the hospital, while the unique constant temperature and humidity requirements of medical buildings further exacerbate the pressure of energy consumption [5]. The full implementation of China's national "dual carbon" action plan in 2025 has significantly increased the urgency of energy conservation and consumption reduction in medical institutions.

As a typical unit of high-energy-consuming areas in hospitals, pediatric wards exhibit a triple superposition effect in their energy consumption characteristics: concentrated spatial heat load caused by dense ward layout, continuous energy demand brought by the family accompanying rate exceeding 80%, and a basic energy consumption pool formed by the all-day operation of medical equipment (such as laminar flow beds). However, most current studies focus on buildings or single functional areas (e.g., operating rooms, diagnosis and treatment areas), lacking detailed analysis of the energy consumption behaviors of different departments and wards within hospitals [6].

Based on this current situation, this study innovatively constructs a three-dimensional interactive and collaborative intervention model of "institutional level—equipment level—behavioral level", and conducts dual verification through a stepped controlled trial design: on the one hand, a self-control design from 2024 to 2025 is adopted to track the energy consumption changes in pediatric wards before and after the intervention; on the other hand, gynecological wards are set as the spatial control group to establish an inter-ward energy efficiency benchmark. By quantitatively evaluating the intervention effect, this study aims to explore a "technology + management + humanity" trinity path of energy conservation and efficiency improvement for medical institutions, provide replicable and promotable solutions, and assist the medical industry in achieving green and low-carbon transformation.

2. Construction of the three-dimensional collaborative intervention mechanism

As the three pillars of organizational management, the institutional level, equipment level, and behavioral level assume core functions of regulating operations, providing technical support, and guiding behaviors, respectively (**Figure 1**). The institutional level offers stability and order for the organization by formulating clear rules, processes, and standards, ensuring efficient collaboration across all links. The equipment level lays a material foundation for efficient operation and sustainable development through physical facilities and technical means, reducing energy consumption and risks. The behavioral level transforms the roles of systems and equipment into practical execution capabilities by standardizing employees' operational habits and strengthening cultural identity, thus promoting the achievement of organizational goals. The intervention mechanism co-constructed by the three levels enables closed-loop management of "rules—technology—practice": the institutional level provides the framework and constraints for the collaborative mechanism, the equipment level offers a guarantee for technical implementation, and the behavioral level ensures execution effects and cultural penetration. Such collaboration not only improves resource utilization efficiency and risk prevention and control capabilities (e.g., multidepartmental collaboration in hospital energy conservation management and psychological crisis intervention) but also optimizes organizational performance through systematic integration, enhances resilience in responding to complex environments, and ultimately achieves sustainable development and value maximization.

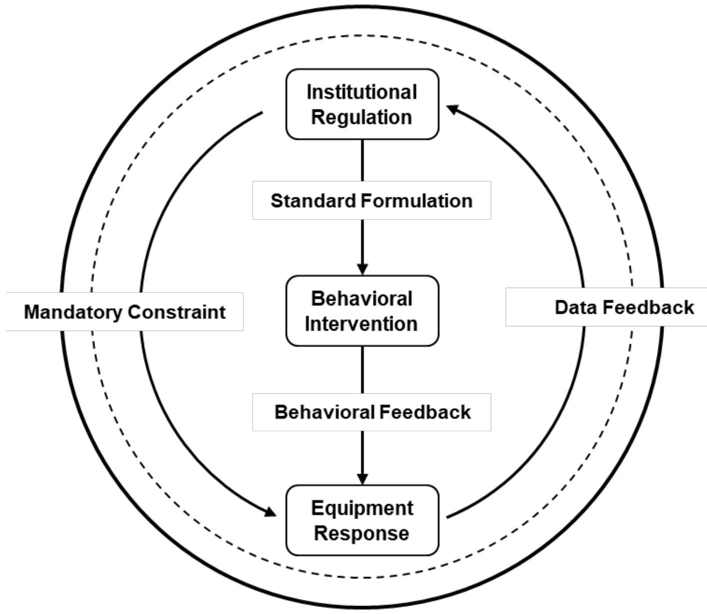

Figure 1. 3D interaction model

3. Methods: Stepped controlled trial design and mechanism implementation path

3.1. Trial design

This study adopted an experimental design combining before-and-after self-control and parallel spatial control. For the experimental group, energy consumption data of pediatric wards from January to June 2025 were selected, with the historical energy consumption data of the same wards during the corresponding period (January to June) in 2024 as the self-control; for the parallel spatial control group, energy consumption data of gynecological wards during the same periods (January to June 2024 and 2025) were used.

The gynecological wards were selected as the spatial control group mainly due to their adjacency to the pediatric wards and location on the same floor, which can effectively control air conditioning load changes caused by floor differences (e.g., higher floors being hotter and lower floors cooler), thereby eliminating the interference of this factor on energy consumption results.

Given that the overall energy consumption level of gynecological wards is usually higher than that of pediatric wards, direct comparison of absolute values is inappropriate. Therefore, this study adopted the difference comparison method to evaluate the energy-saving effect. Specifically, by calculating the difference in electricity consumption between pediatric and gynecological wards during the corresponding period in 2024 and comparing it with the difference during the same period in 2025, the actual electricity-saving effect of pediatric wards after implementing the energy-saving intervention measures based on the three-dimensional collaborative mechanism in 2025 was further verified (**Table 1**).

Table 1. Trial control design

Group	Data source	Time period	Description
Experimental Group	Pediatric Ward	2025.01-2025.06	Energy consumption data after implementing energy-saving intervention measures
Before-and-after Self-Control Group	Pediatric Ward	2024.01-2024.06	Historical data of the same period without implementing energy-saving intervention measures
Parallel Spatial Control Group	Gynecological Ward	2024.01-2024.06 2025.01-2025.06	Without energy-saving intervention, used to calculate the energy consumption difference with the experimental group to control the impact of time changes and external environments

3.2. Operational plan of the mechanism

3.2.1. Institutional level

The institutional level provides a standardized framework and implementation guarantee for energy conservation management through systematic rules and process design. Regarding the setting and management of air conditioning temperatures, relevant studies have shown that for every 1 °C increase in air conditioning temperature, the operating power of the compressor can decrease by approximately 7%–10%. Raising the set temperature from 25 °C to 26 °C in summer can save about 5%–10% of the total electricity consumption [7]. International standards such as ASHRAE 55 and EN 15251 specify that the comfortable temperature range is 23 °C–26 °C in summer and 20 °C–24 °C in winter. Within this range, the human body experiences the most thermal comfort and is less prone to discomfort [8]. Therefore, by collaborating with the logistics management department, the constant temperature of the central air conditioning system was set (26 °C in summer and 22 °C in winter), with clear regulations that doors and windows must be closed when the air conditioning is in use, and operation with open windows is prohibited to reduce energy waste. Energy conservation publicity and supervision are carried out by posting "Save electricity and turn off lights when leaving" signs near switches in wards and toilets to popularize energy-saving concepts among patients and their families. Meanwhile, nurses are required to actively check electricity usage during ward rounds to reduce unnecessary lighting. Time-phased electricity management further refines operational standards. For instance, during the lunch break (12:30—14:30), the main light strips in corridors and the lighting in corridors of office and living areas are turned off with one click; after 20:00, when pedestrian traffic in corridors is scarce, the main light strips in ward corridors and the lighting in office and living areas are switched off, with only basic brightness maintained; after 22:00, the auxiliary light strips in corridors are turned off. Regarding the scientific use of office equipment, it is specified that some devices (e.g., computers and printers) should be shut down after the P shift (18:00), and only one device is reserved for nursing documentation after the N shift (22:00) to minimize standby energy consumption. Through the full-chain standardization of temperature control, publicity and supervision, time-phased management, and equipment use at the institutional level, not only were refined energy-saving goals achieved, but also the combination of rule constraints and behavioral guidance promoted the improvement of organizational resource utilization efficiency and sustainable development.

3.2.2. Equipment level

The equipment level provides a solid material guarantee for the efficient operation and sustainable development of the organization through scientific maintenance and technical optimization. Studies have shown that cleaning air conditioners can reduce filter resistance and fan power, thereby lowering energy consumption and extending equipment service life [9–10]. Therefore, in terms of equipment maintenance and efficiency optimization, the logistics management department shall establish a systematic maintenance mechanism to ensure that key components such as air conditioning filters are regularly cleaned and replaced, thereby maintaining the equipment in a continuous optimal operating state. Specifically, the cleaning and replacement cycle of air conditioning filters should be dynamically adjusted based on the actual usage frequency of the equipment and the dust concentration of the surrounding environment: regular cleaning is usually performed monthly, while deep cleaning or replacement is required quarterly to sustain efficient equipment operation and reduce energy consumption. In addition, the role of the equipment level is not limited to the maintenance of individual devices, but also requires ensuring the stability and economy of the overall system through full-life-cycle management (e.g., regular inspection and maintenance of lighting systems, testing of energy consumption of office equipment). For example, conducting energy efficiency evaluations on lighting equipment such as corridor light strips and ward lighting, selecting low-power LED lamps, and optimizing control logic can further reduce power consumption during off-peak periods. The refined management at the equipment level not only directly improves resource utilization efficiency but also provides reliable technical support for the implementation of rules at the institutional level (e.g., time-phased electricity management) and energy-saving practices at the behavioral level (e.g., turning off lights when leaving). It forms a closed loop of "technical empowerment—rule constraints—behavioral collaboration", ultimately achieving a win-win situation between energy-saving goals and organizational benefits.

3.2.3. Behavioral level

By standardizing employees' operational habits and daily practices, the behavioral level transforms energy-saving concepts into actionable guidelines, serving as a key support for the collaborative implementation of systems and equipment. Regarding energy management in unoccupied areas, it is clearly required that air conditioning and lighting in non-active areas such as lecture rooms, wards, duty rooms, and offices must be turned off when unoccupied to avoid energy waste. Meanwhile, it is emphasized that all equipment in unoccupied areas (e.g., air conditioning and lighting in wards, offices, and duty rooms) should be fully inspected and turned off after work, forming a behavioral norm of "turning off power when leaving." Regarding lighting and natural light utilization, the priority use of natural light is advocated to reduce the frequency of lighting fixture usage, with the requirement of "turning off lights when leaving." For example, during periods of sufficient natural light, the main light strips in ward corridors or lighting in office areas are turned off, retaining only the necessary basic brightness. In addition, regarding ventilation and air conditioning usage habits, nurses actively guide patients to turn off the air conditioning and open windows for ventilation during morning and evening nursing rounds, which not only improves indoor air circulation but also reduces the operating load of the air conditioning. Through the standardization of daily operational details (e.g., regular inspections and active reminders), these specific behavioral norms not only strengthen energy conservation awareness but also form a closed loop with the time-phased management rules at the institutional level (e.g., turning off corridor light strips during lunch breaks) and the optimized maintenance at the equipment level (e.g., cleaning air conditioning filters). They jointly promote the achievement of resource conservation goals, ultimately establishing a trinity of sustainable management mechanisms featuring "rule constraints—technical guarantees—behavioral practices."

4. Discussion on energy saving effects

This study adopted a quasi-experimental design combining before-and-after self-control and parallel spatial control to systematically evaluate the electricity-saving effectiveness of the "institution-equipment-behavior" three-dimensional collaborative intervention mechanism. Electrical equipment in hospital wards is classified into four categories: lighting equipment, air conditioning equipment, office equipment, and clinical medical equipment. Among these, clinical medical equipment is classified as an essential electrical load and excluded from the scope of electricity-saving interventions; energy-saving measures mainly target lighting, air conditioning, and office equipment. When analyzing energy-saving effects, the baseline energy consumption of clinical medical equipment is deducted from the total electricity consumption to accurately reflect the impact of intervention measures on the target equipment.

The results of the before-and-after self-control in the pediatric ward (**Table 2**) showed that after the implementation of the multi-dimensional collaborative intervention, the total electricity consumption from January to June 2025 decreased significantly compared with the same period in 2024. The average monthly electricity savings exceeded 900 kWh, with an average electricity saving rate of over 20%. To exclude interference from external factors such as climate, this study introduced the gynecological ward as a parallel spatial control. No energy-saving measures were implemented in this ward, and its energy consumption in the same period of 2025 fluctuated minimally compared with 2024 (the average monthly electricity consumption was 7587.44 kWh and 7653.59 kWh, respectively, with a difference of only 0.08%).

Given that the overall energy consumption level of the gynecological ward is usually higher than that of the pediatric ward, this study adopted a difference comparison method for in-depth analysis. By calculating the monthly electricity consumption difference between the pediatric and gynecological wards from January to June 2024 and 2025 (**Table 3**) and plotting a comparative line chart (**Figure 2**), it was found that the average monthly electricity consumption of the pediatric ward from January to June 2024 was 4269.66 kWh, which was 44.21% lower than that of the gynecological ward. In 2025, after the implementation of electricity-saving interventions, the electricity consumption of the pediatric ward further decreased, and the difference from the gynecological ward expanded to 56.17% (pediatric ward: 3255.11 kWh vs. gynecological ward: 7587.44 kWh). **Figure 2** shows that the monthly electricity consumption difference curve from January to June 2025 shifted upward overall. This result strongly supports that the electricity-saving effect stems from the three-dimensional collaborative intervention mechanism rather than changes in the external environment over the years.

Table 2. Comparison of electricity consumption in pediatric ward between January–June 2024 and January–June 2025 (Unit: kWh)

Month	Self-Time Control			
	2024	2025	Energy Saving Effect	
	Electricity Consumption of Target Control Electrical Equipment	Electricity Consumption of Target Intervention Electrical Equipment	Electricity Saving	Electricity Saving Rate
January	4131.13	3422.27	708.86	17.16%
February	3391.18	2955.88	435.3	12.84%
March	4359.38	3152.67	1206.71	27.68%
April	4766.13	3325.4	1440.73	30.23%
May	4818.02	3341.77	1476.25	30.64%
June	4152.12	3752.66	399.46	9.62%
Average	4,269.66	3,325.11	944.55	21.36%

Table 3. Statistics of electricity consumption in pediatric and gynecological wards from January to June 2024 and 2025 (Unit: kWh)

Month	Spatial Control					
	2024		2025		Pediatric vs. Gynecological Reduced Electricity Consumption	
	Pediatric Target Intervention Electrical Equipment Consumption	Gynecological Target Control Electrical Equipment Consumption	Pediatric Target Intervention Electrical Equipment Consumption	Gynecological Target Control Electrical Equipment Consumption	2024	2025
January	4131.13	6,882.84	3422.27	6509.23	2751.71	3086.96
February	3391.18	6,399.78	2955.88	6,129.91	3,008.60	3174.03
March	4359.38	7,337.96	3152.67	8,475.48	2,978.58	5322.81
April	4766.13	8,459.69	3325.4	7,484.14	3,693.56	4158.74
May	4818.02	8,498.10	3341.77	8,788.33	3,680.08	5446.56
June	4152.12	8,343.18	3752.66	8,137.54	4,191.06	4,384.88
Average	4,269.66	7,653.59	3,325.11	7,587.44	3,383.93	4,262.33

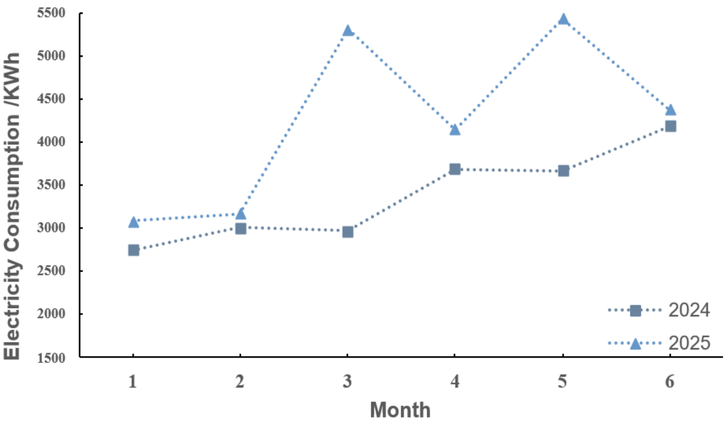

Figure 2. Reduced power consumption in pediatrics vs. gynecology

5. Conclusion

By constructing and practicing the "institutional—equipment—behavioral" three-dimensional collaborative intervention mechanism, this study significantly reduced the non-medical electricity consumption of the pediatric ward, with an electricity-saving rate exceeding 20%. This proves that the model can effectively integrate technical optimization, management standardization, and behavioral guidance to achieve refined energy-saving goals. The multi-dimensional controlled trial design scientifically excludes interfering factors such as climate and floor environment, enhancing the reliability of the conclusions. This practice not only provides a reusable systematic solution for energy conservation management in pediatric wards but also offers empirical support for medical institutions to promote overall green and low-carbon development. It can be promoted and further practiced at more ward levels in the future.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Bawaneh K, Ghazi Nezami F, Rasheduzzaman M, et al., 2019, Energy Consumption Analysis and Characterization of Healthcare Facilities in the United States. Energies, 12(19): 3775.

[2] Kruger J, 2023, Decarbonizing Health Care: Clean Energy Policy Options. Georgetown Climate Center. https://www.georgetownclimate.org/files/report/Decarbonizing_Health_Care_Clean_Energy_Policy_Options.pdf

[3] Dolcini M, Brambilla A, Mangili S, et al., 2025, Environmental Sustainability in Next-Generation Hospitals. Identifying Needs and Requirements from Healthcare Organizations and Industry Stakeholders. Annali di Igiene: Medicina Preventiva e di Comunita, 37(5): 565–573.

[4] Selvakumar P, Muralidharan V, Kumar GS, et al., 2025, Reducing the Carbon Footprint in Healthcare. Journal of Environmental Nanotechnology, 14(1): 453–463.

[5] Zhang L, Zhang R, Ma Y, et al., 2024, Exploring Carbon Emission Accounting Methods for Typical Public Institutions: A Case Study of Hospitals. Energy Informatics, 7(1): 35.

[6] Coccagna M, Cesari S, Valdiserri P, et al., 2017, Energy Consumption in Hospital Buildings: Functional and Morphological Evaluations of Six Case Studies. International Journal of Environmental Science, 2017(2): 443–452.

[7] Wang Q, Meng QL, 2015, Measured Study on the Effect of Air Conditioner Setting Temperature on Electricity Consumption in Summer. Building Energy Conservation, 43(11): 5.

[8] Duran O, 2018, Evaluation of Retrofitting Strategies for Post-war Office Buildings, thesis, Loughborough University.

[9] Kermeli K, Deuchler R, Worrell E, et al., 2006, Energy Efficiency and Cost Saving Opportunities for Metal Casting. https://www.energystar.gov/sites/default/files/tools/ENERGY%20STAR%20Metal%20Casting%20Energy%20Guide.pdf

[10] Montgomery RD, Baker R, 2006, Study Verifies Coil Cleaning Saves Energy. Ashrae Journal, 48(11): 34–38.