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Evaluating the impact of AED training on nurses' emergency response capabilities in China: a cross-sectional survey

Qingxiu Long[1*] and Zhenyu Luo[1]

Abstract

Background Automated external defibrillators (AEDs) are critical in emergency cardiac care. However, significant gaps in nurses' knowledge and confidence in using AEDs limit their effectiveness. This study explores the current status of AED training and its impact on nurses' emergency response capabilities across municipal-level and county-level hospitals in China.

Methods A cross-sectional survey was conducted from May 20 to August 1, 2024, via telephone and electronic questionnaires in the emergency, intensive care unit (ICU), and general wards of 12 municipal and county-affiliated hospitals. A total of 451 questionnaires were distributed, with 440 valid responses (response rate: 97.6%). Data were analyzed using chi-square tests and multivariate logistic regression in SPSS 24.0 ($P < 0.05$ considered significant). Key factors influencing AED knowledge and confidence included additional training, hands-on drills, and defibrillation experience.

Results Only 17.5% of nurses demonstrated sufficient AED knowledge, and 15.9% reported confidence in defibrillation. In municipal-level hospitals, nurses outperformed county hospitals in training access and proficiency. Additional training (OR = 24.50, $p < 0.0001$) and practical drills (OR = 12.36, $p < 0.0001$) were strongly associated with improved knowledge and confidence.

Conclusions The study highlights the need for enhanced AED training, emphasizing practical drills and scenario-based simulations, particularly in resource-limited county hospitals. Targeted strategies could significantly improve nurses' emergency response capabilities, contributing to better cardiac arrest outcomes.

Keywords Nurse, Automated external defibrillator training, Automated external defibrillator, Emergency care, Knowledge level, Confidence

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Introduction

Sudden cardiac arrest remains a leading cause of in-hospital and out-of-hospital mortality worldwide [1–3]. Automated external defibrillators (AEDs) are critical in cardiac emergency care, improving survival rates through rapid ECG analysis and automated defibrillation [4–6]. However, their effectiveness depends not only on technical performance but also on the operator's proficiency. As primary responders, nurses must be competent in AED operation [7]. Despite widespread emergency training in hospitals, many nurses still lack AED knowledge and confidence, with disparities influenced by hospital resources, training frequency, and practical exposure [8–10].

Most AED research focuses on technological advancements and clinical outcomes [11], while systematic evaluations of training effectiveness remain limited. Existing studies are often confined to single hospitals or specific regions [12], lacking large-scale cross-sectional analyses of training practices. Many programs emphasize theoretical instruction [13] with insufficient hands-on training, especially in resource-limited county hospitals, further reducing training effectiveness [14]. Additional emergency training and practice drills significantly enhance nurses' AED proficiency and confidence [15]. However, training models vary between municipal and county hospitals [16, 17]. Municipal hospitals integrate theoretical and practical training, while county hospitals often lack hands-on practice, limiting emergency response capability. Despite these differences, systematic evaluations of training effectiveness across hospital types are still lacking.

This multicenter cross-sectional study systematically assesses AED training among nurses in municipal and county hospitals since 2016, analyzing the impact of theoretical instruction and hands-on drills on knowledge and confidence while identifying key influencing factors. The study uses multivariate logistic regression to explore the combined effects of hospital level, work experience, and practical exposure on emergency care skills. This research addresses gaps in systematic evaluations of emergency training, providing evidence for optimizing hospital and nursing school training strategies. The findings contribute to AED education, advance related research, enhance nurses' emergency response capabilities, and support improvements in cardiac arrest management and national emergency care systems.

Materials and methods

Study subjects and design

This study employed a cross-sectional design conducted from May 20 to August 1, 2024, using telephone and electronic questionnaires. Researchers contacted the nursing departments of 12 municipal-level and affiliated county-level hospitals to inquire about AED and defibrillation training for nurses since 2016, using a set of six questions. Before the survey, researchers explained the study's purpose to respondents and obtained informed consent over the phone. The nursing departments of 12 municipal and county-affiliated hospitals identified eligible participants. Inclusion criteria were: (1) registered nurses working in emergency, intensive care, or general wards with potential AED use; (2) participation in at least one public emergency training since 2016; and (3) voluntary consent. A total of 451 nurses received the questionnaire, with 440 valid responses collected. The study was approved by the REDACTED Ethics Committee.

Questionnaire design

The questionnaire consisted of three sections and 16 questions. All questions were developed and evaluated by nursing experts from the emergency departments of three tertiary hospitals (supplementary materials). A pilot test was conducted with 12 nurses, and a retest was performed one week later. The Cronbach's α coefficient for the two tests was 0.97, indicating good internal consistency.

Before completing the questionnaire, participants were informed about the study's purpose, informed consent, and the judgment criteria for assessing their AED knowledge, ensuring they understood how their responses would be evaluated, particularly for AED functions, defibrillation procedures, and practical use. The first section of the questionnaire collected basic information about the participants, including their department, gender, age, work experience, and educational background. The second section focused on the training they had received since 2016. The third section assessed nurses' knowledge and confidence in using AEDs; questions 8, 9, and 10 were multiple-choice questions about AED knowledge used to determine whether participants were adequately informed about AED use. If all three questions were answered correctly, the participant was considered to have sufficient knowledge of AEDs; otherwise, they were considered not adequately informed.

Statistical analysis

Data was analyzed using SPSS software (version 23.0; IBM SPSS Statistics). Categorical variables were analyzed using the chi-square test, while ordinal data were analyzed using the Mann-Whitney U test. Multivariate logistic regression analysis was used to identify influencing factors. A p-value of <0.05 was considered statistically significant.

Results

Analysis of AED and defibrillation training status in municipal-level and county-level hospitals

The study conducted a telephone survey of 12 hospitals (Table 1). The results showed that only 2 (40%) municipal-level hospitals were equipped with AEDs, while 3 (60%) municipal-level hospitals had no AED devices. All 7 (100%) county-level hospitals lacked AED equipment. Since 2016, 3 (60%) municipal-level hospitals have organized 1–2 AED training sessions for nurses, while 2 (40%) organized 3–4 sessions; in contrast, all county-level hospitals organized only 1–2 sessions. Regarding the training format, 3 (60%) municipal-level hospitals offered theoretical training only, while 2 (40%) provided a combination of theory and practice. County-level hospitals, however, exclusively offered theoretical training. In addition, all surveyed hospitals provided defibrillation training for nurses. In municipal-level hospitals, 100% organized 5–6 defibrillation training sessions, 6 (85.7%) county-level hospitals organized 3–4 sessions, and 1 (14.3%) organized 5–6 sessions. In terms of training format, all municipal-level hospitals used a combination of theory and practice, while 6 (85.7%) county-level hospitals also combined theory and practice, and 1 (14.3%) provided theoretical training only.

Survey results of nurses' general information and analysis of AED knowledge and confidence

Table 2 presents the survey results on nurses' general information, AED knowledge, and confidence. A total of 440 valid responses were categorized into two groups: sufficient (77 nurses, 17.5%) and insufficient (363 nurses, 82.5%) AED knowledge. Nurses in municipal hospitals had significantly higher levels of AED knowledge, with 54 (70.1%) of 77 nurses in municipal hospitals having sufficient knowledge compared to 23 (29.9%) of 77 nurses in county hospitals ($p = 0.003$). Age distribution showed no significant differences in AED knowledge ($p = 0.885$), and work experience was not associated with AED knowledge mastery ($p = 0.587$).

Regarding training, 27 nurses (6.1%) attended additional AED training outside their hospital, with significantly more nurses with sufficient knowledge (19, 24.7%) compared to those with insufficient knowledge (8, 2.2%, $p < 0.001$). Participation in AED drills was reported by 47 nurses (10.6%), with 27 (35.1%) of those with sufficient knowledge participating in multiple drills, compared to 4 (1.1%) with insufficient knowledge ($p < 0.01$).

The table also shows that 43 nurses (9.8%) reported participation in actual defibrillation, and 70 nurses (15.9%) expressed confidence in performing AED defibrillation. A significant relationship was found between AED knowledge and confidence, with 39 (50.6%) of nurses with sufficient knowledge feeling confident in performing actual AED defibrillation, compared to 31 (8.5%) of those with insufficient knowledge ($p < 0.01$).

Analysis of factors influencing nurses' AED knowledge mastery

Multivariate logistic regression analysis was conducted to identify factors influencing nurses' AED knowledge mastery. The results showed that participation in additional AED training (odds ratio (OR) = 24.5, 95% confidence interval (CI) 9.659–67.69, $p < 0.0001$) and AED drills (OR = 12.4, 95% CI 6.3–26.8, $p < 0.0001$) significantly impacted nurses' AED knowledge mastery (Fig.

Table 1 The results of telephone surveys

	Urban ($n = 5$)	County ($n = 7$)
Have any AEDs*N*, (%)		
Yes	2 (40%)	0 (0.0%)
No	3 (60.0%)	7 (100.0%)
How many times that AEDs training been organized for nurses since 2016		
1 ~ 2	3 (60.0%)	7 (100.0%)
3 ~ 4	2 (40.0%)	0 (0.0%)
How the AEDs training conducted		
Theoretical	3 (60.0%)	7 (100.0%)
Theoretical and practical	2 (40.0%)	0 (0.0%)
Have organized defibrillation training for nurses		
Positive	5 (100.0%)	7 (100.0%)
Negative	0 (0.0%)	0 (0.0%)
How many times that defibrillation training have organized for nurses since 2016		
3 ~ 4	0 (0.0%)	6 (85.7%)
5 ~ 6	5 (100.0%)	1 (14.3%)
How the defibrillation training conducted		
Theoretical	0 (0.0%)	1 (14.3%)
Theoretical and practical	5 (100.0%)	6 (85.7%)

Table 2 Demographic and AED-related knowledge characteristics of survey responders

	Overall (*n* = 440)	Sufficient (*n* = 77)	Insufficient (*n* = 363)	*p* value
Area				0.003
Municipal	242 (55.0)	54 (70. 1)	188 (51.8)	(Pearson Chi-Square 8.632)
County	198 (45.0)	23 (29.9)	175 (48.2)	
Gender				0.266
Male	23 (5.2)	6 (7.8)	17 (4.7)	
Female	417 (94.8)	71 (92.2)	346 (95.3)	
Age				0.885
20 ~ 30	139 (31.6)	23 (29.9)	116 (32.0)	
31 ~ 40	206 (46.8)	38 (49.4)	168 (46.3)	
41 ~ 50	95 (21.6)	16 (20.8)	79 (21.8)	
Work experience				0.587
< 3	46 (10.5)	7 (9. 1)	39 (10.7)	
3 ~ 5	50 (11.4)	10 (13.0)	40 (11.0)	
6 ~ 10	110 (25.0)	16 (20.8)	94 (25.9)	
11 ~ 20	193 (43.9)	39 (50.6)	154 (42.4)	
> 20	41 (9.3)	5 (6.5)	36 (9.9)	
Educational background				0.694
Bachelor	426 (96.8)	74 (96. 1)	352 (97.0)	
Master	14 (3.2)	3 (3.9)	11 (3.0)	
Ever attended extra AED training not organized by your hospital				< 0.001
Yes	27 (6. 1)	19 (24.7)	8 (2.2)	
No	413 (93.9)	58 (75.3)	355 (97.8)	
How many times of drills have you ever performed with an AED				< 0.01 (141.038)
None	393 (89.3)	40 (51.9)	353 (97.2)	
One time	16 (3.6)	10 (13.0)	6 (1.7)	
More than one time	31 (7.0)	27 (35. 1)	4 (1. 1)	
Ever take part in any actual defibrillation				0.519
Yes	43 (9.8)	6 (7.8)	37 (10.2)	
No	397 (90.2)	71 (92.2)	326 (89.8)	
Ever take part in any actual defibrillation with AEDs				
None	440	77	363	
One time	0	0	0	
More than one time	0	0	0	
Have confidence in using an AED in actual defibrillation				< 0.01 (84. 199)
Yes	70 (15.9)	39 (50.6)	31 (8.5)	
No	370 (84.1)	38 (49.4)	332 (91.5)	

1; Table 3). Furthermore, the chi-square test revealed a significant association between area (municipal and county-level) and AED knowledge mastery, with nurses in municipal hospitals demonstrating significantly higher AED knowledge mastery compared to those in county hospitals. Additional AED training, participation in AED drills, and experience with actual defibrillation were also positively correlated with AED knowledge mastery (Table 4).

Analysis of factors influencing nurses' confidence in AED use

Multivariate logistic regression analysis was conducted to identify the key factors influencing nurses' confidence in using AEDs. The results showed that location (OR = 2.2, 95% CI 1.1–4.3, $p = 0.0213$), work experience (OR = 0.9, 95% CI 0.8-1.0, $p = 0.0429$), participation in additional AED training (OR = 3.0, 95% CI 1.1–7.4, $p = 0.0211$), frequency of AED drills (OR = 3.9, 95% CI 2.3–6.8, $p < 0.0001$), and experience with actual defibrillation (OR = 8.7, 95% CI 4.2–18.2, $p < 0.0001$) significantly influenced nurses' confidence in using AEDs (Fig. 2; Table 5). Furthermore, the chi-square test revealed a positive correlation between additional AED training, participation in AED drills, experience with actual defibrillation, and confidence in AED use (Table 6).

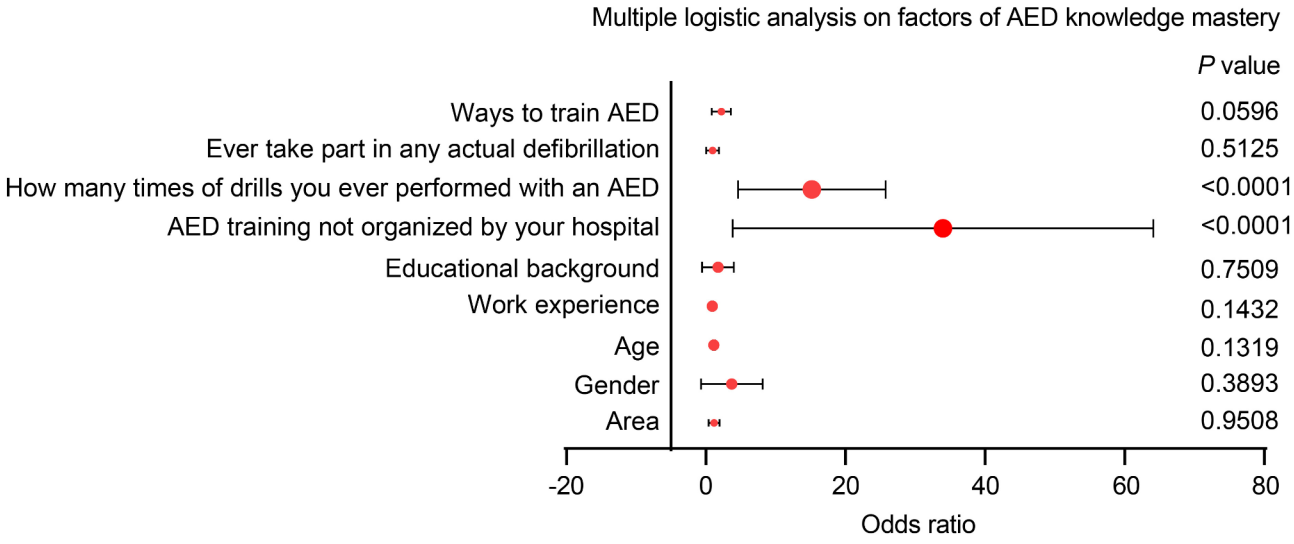

Fig. 1 Multiple logistic analysis of factors influencing nurses' mastery of AED knowledge

Table 3 Multiple logistic analysis on factors influencing nurses' mastery of AED knowledge

	Parameter	Standard error	OR	OR 95% CI	Z	*p* value
Area	-0.02	0.4	0.9	0.5to 2.0	0.1	0.9508
Gender	0.6	0.7	1.9	0.5 to 8.7	0.9	0.3893
Age	0.1	0.1	1.1	1.0 to 1.3	1.5	0.1319
Work experience	-0.1	0.01	0.9	0.8 to 1.0	1.5	0.1432
Educational background	-0.3	1.0	0.7	0.1 to 4.3	0.3	0.7509
AED training not organized by your hospital	3.2	0.5	24.5	9.7 to 67.7	6.5	< 0.0001
How many times of drills you ever performed with an AED	2.5	0.4	12.4	6.3 to 26.8	6.8	< 0.0001
Ever take part in any actual defibrillation	-0.4	0.6	0.7	0.2 to 2.0	0.7	0.5125
Ways to train AED	0.6	0.3	2.0	1.0 to 3.7	1.9	0.0596

Table 4 Chi-square test of AED knowledge mastery

	Knowledge of AEDs	
	Chi-square	*p* value
Area	8.6	0.0033
Ever attended extra AED training not organized by your hospital	55.7	< 0.0001
How many times of drills have you ever performed with an AED	53.3	< 0.0001
Ever take part in any actual defibrillation	84.2	< 0.0001

Discussion

Through a cross-sectional survey of nurses from 12 municipal and county-level hospitals, this study reveals significant differences in AED knowledge levels and operational confidence among nurses across different hospital types. With the global rise in sudden cardiac arrest (SCA) incidents, AEDs—portable and user-friendly emergency care devices—have become increasingly important in public spaces and healthcare facilities [18]. AEDs can automatically analyze electrocardiograms and provide shock recommendations during emergency care, greatly improving survival rates for cardiac arrest patients [19]. Although the Chinese government has supported AED deployment in public spaces since 2016 [20], hospitals have not received direct funding to procure AEDs or train healthcare staff. This study's findings show that municipal hospital nurses exhibit higher AED knowledge and practical skills compared to county hospital nurses, with additional training and hands-on exercises playing a critical role in improving knowledge mastery and operational confidence. Consistent with previous literature on emergency care training effectiveness, this study's larger, cross-hospital sample enhances the representativeness and generalizability of the results. These findings underscore the importance of strengthening emergency care resource allocation and training funding support within hospitals.

Compared to previous studies, our findings reveal both consistencies and differences. While past literature underscores AED as a cost-effective defibrillation device

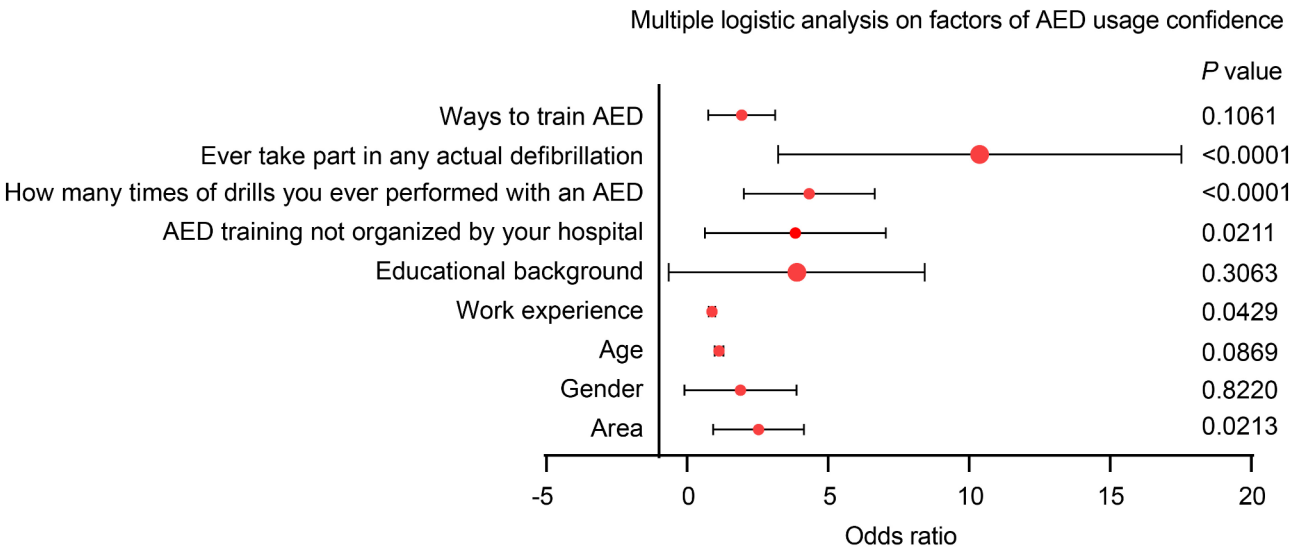

Fig. 2 Multiple logistic analysis of factors influencing nurses' confidence in using AED

Table 5 Multiple logistic analysis on factors influencing nurses' confidence in using an AED in actual defibrillation

	Parameter	Standard error	OR	OR 95% CI	Z	*p* value
Area	0.8	0.3	2.1	1.1 to 4.3	2.3	0.0213
Gender	0.1	0.6	1.1	0.4to 4.1	0.2	0.8220
Age	0.1	0.07	1.1	0.9 to 1.3	1.7	0.0869
Work experience	-0.1	0.07	0.8	0.7 to 0.9	2.0	0.0429
Educational background	0.6	0.8	2.2	0.4 to 9.0	1.0	0.3063
AED training not organized by your hospital	1.1	0.5	3.0	1.1 to 7.4	2.3	0.0211
How many times of drills you ever performed with an AED	1.4	0.3	3.9	2.3 to 6.8	4.8	< 0.0001
Ever take part in any actual defibrillation	2.2	0.4	8.7	4.2 to 18.2	5.8	< 0.0001
Ways to train AED	0.5	0.3	1.7	0.9 to 3.2	1.6	0.1061

Table 6 Chi-square test of AED usage confidence

	Confidence in using an AED	
	Chi-square	*p* value
Ever attended extra AED training not organized by your hospital	9.6	0.0019
How many times of drills have you ever performed with an AED	32.6	< 0.0001
Ever take part in any actual defibrillation	38.6	< 0.0001

suitable for SCA emergency care [21], it often overlooks the challenges hospitals face in implementing AED training under resource constraints. In mainland China, the cost of a single AED exceeds 20,000 RMB, with additional expenses for electrode replacement. Without government funding, financially constrained hospitals, particularly county-level facilities, struggle to procure and maintain AEDs. This study found that none of the county hospitals had AEDs, while the availability in municipal hospitals was only 40%, highlighting disparities in emergency resource allocation. Such shortages weaken hospitals' emergency response capabilities and limit nurses' AED training opportunities.

Key factors contributing to this shortage include policy prioritization of AED deployment in public spaces over hospitals, high procurement and maintenance costs, and reliance on traditional manual defibrillators, restricting AED adoption. As a result, county hospital nurses receive inadequate AED training, especially lacking hands-on experience [22]. Only 9.8% of surveyed nurses had actual defibrillation experience, reflecting a gap in practical training within the current healthcare system, which affects skill acquisition and emergency preparedness.

Previous studies suggest AEDs are "easy to use," leading to a focus on theoretical knowledge while neglecting hands-on training and frequent practice [12]. Multivariate analysis indicates that additional AED training and hands-on drills significantly improve nurses' knowledge and confidence. However, county hospital nurses struggle to gain practical experience without AED access, making it difficult to build confidence in clinical practice. Strengthening simulation-based and hands-on training is

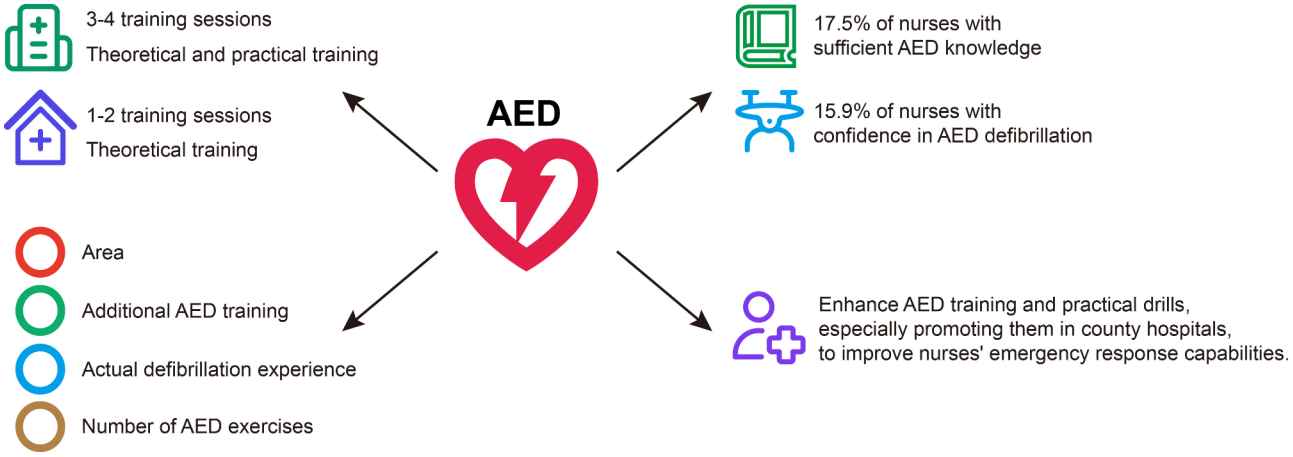

Fig. 3 Visual analysis of the current status of AED training for nurses and recommendations for improvement

essential to mitigate the impact of equipment shortages, enhance AED training quality, and improve nurses' emergency response capabilities.

The clinical significance of this study lies in identifying variations in AED training among nurses across different hospital levels, enabling more targeted emergency care training strategies. Municipal hospitals should increase practical drills and scenario-based simulations, while county hospitals need more resource support to ensure adequate nurse training. This study highlights that improving AED accessibility is crucial for optimizing training outcomes, particularly in county hospitals. We recommend government agencies implement policies to promote AED deployment within hospitals and provide financial support to reduce regional disparities in emergency care resources. Additionally, hospitals could establish joint training programs, allowing county hospital nurses to undergo regular hands-on AED training in municipal hospitals to compensate for their resource limitations.

This study has several limitations. First, although the sample includes 12 hospitals, they are confined to a specific region, which may limit the geographic representativeness of the findings. Additionally, the study employed a cross-sectional design with data primarily based on self-reports, introducing potential recall bias and subjectivity. The lack of objective assessment tools, such as hands-on operational tests, may also limit the accuracy of reflecting nurses' actual skill levels. These limitations impact the interpretation and generalizability of the results. Future studies should expand the sample coverage and incorporate practical performance assessments and scenario simulations to comprehensively evaluate nurses' AED proficiency.

Future research should address the unresolved issues identified in this study by exploring strategies to optimize AED training models for nurses in county hospitals. Specifically, studies should investigate methods for implementing efficient, practical drills and scenario simulations within limited-resource settings. Additionally, examining the long-term effects of different training models will be essential to identify the most effective strategies. Future studies should also consider integrating public emergency care training with hospital training to establish a comprehensive, systematic emergency care training framework to enhance emergency care capabilities in hospitals and communities.

Conclusion

This study shows nurses' significant deficiencies in AED training and knowledge mastery, particularly in practical experience and confidence levels (Fig. 3). Although hospitals have gradually implemented AED-related training since 2016, municipal-level hospitals offer more comprehensive and frequent training than county-level hospitals, emphasizing practical training. Nurses who received additional AED training and participated in practical drills showed significant improvements in knowledge mastery and confidence. These findings highlight the need for further enhancement of AED training programs.

What's new and important

- This study is among the first to comprehensively analyze disparities in AED training and operational confidence among nurses across municipal-level and county-level hospitals in China.
- Hands-on AED drills and additional training significantly enhanced nurses' knowledge and confidence in emergency care.
- The findings provide actionable recommendations for developing tailored, resource-sensitive training programs for county hospitals to improve emergency response capabilities and patient survival rates.

- This research supports the implementation of more practical, scenario-based simulations in nursing education to bridge the gap between theoretical knowledge and real-world application.

Abbreviations

AED	Automated External Defibrillator
CI	Confidence Interval
OR	Odds Ratio
SCA	Sudden Cardiac Arrest

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12912-025-03036-6.

Supplementary Material 1

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None.

Author contributions
Qingxiu Long and Zhenyu Luo conceived and designed the study. Qingxiu Long conducted the cross-hospital survey, coordinated the data collection process, and supervised the study implementation. Zhenyu Luo developed the questionnaire, performed the statistical analyses, and interpreted the data. Qingxiu Long wrote the first draft of the manuscript, while Zhenyu Luo provided critical revisions and additional insights into the discussion and conclusions. Both authors reviewed and approved the final version of the manuscript for submission. Qingxiu Long takes responsibility for the integrity of the data and the accuracy of the analysis.

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Data availability
All data can be provided as needed.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was deemed unnecessary as the study did not involve any human intervention, biological sampling, or identifiable personal information. The Ethics Committee of Guangyuan Central Hospital approved the exemption from ethical review. Informed consent to participate in this study was obtained from all participants. Before completing the questionnaire, participants were provided with detailed information about the study's purpose, procedures, and data usage. Participation was entirely voluntary, and all data were collected anonymously.

Consent to publish
Not applicable.

Competing interests
The authors declare no competing interests.

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