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ORIGINAL RESEARCH

Analysis of factors influencing the acquisition of basic life support knowledge among standardized training trainees

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Abstract

Cardiopulmonary resuscitation (CPR) significantly impacts the treatment success of cardiac arrest patients and serves as a simple and practical basic life support (BLS) skill. However, there is a lack of analysis regarding factors influencing BLS knowledge acquisition by trainees after training. In this study, we analyzed and explored this issue based on assessments of 385 trainees newly enrolled in standardized residency training at West China Hospital, Sichuan University in 2022. They came from various medical institutions and underwent a 3-day systematic training in basic life support skills. At the end of the training, their knowledge acquisition was analyzed through an examination. The results indicated that BLS knowledge acquisition scores among these 385 resident trainees were not significantly different in age, gender, education, length of service, professional title, or teaching style preference. However, two factors demonstrated significant influence: the trainees' profession type ($F = 39.45$, $p < 0.001$) and previous BLS training ($t = -4.42$, $p < 0.001$). Linear regression analysis indicated that technicians had a 12% lower BLS accuracy compared to doctors ($\beta = -0.12$, $p < 0.001$), while those who had received prior BLS training exhibited an 8% higher accuracy compared to those who had not ($\beta = 0.08$, $p < 0.001$). Thus, it is important to focus on enhancing BLS knowledge and skills among technician trainees in residency training. Additionally, increased standardization in BLS training can prove beneficial in improving trainees' comprehension and mastery of BLS knowledge.

Keywords

Basic life support; Cardiopulmonary resuscitation; Trainees; Accuracy

1. Background

The increasing prevalence of cardiovascular disease and the rising incidence of cardiac arrests (CA) are imposing substantial economic burdens on healthcare systems worldwide [1]. Basic life support (BLS) represents an important form of emergency assistance administered either by healthcare professionals or the general populace before patients reach a healthcare facility or when confronted with life-threatening conditions [2]. Proficiency in BLS and cardiopulmonary resuscitation (CPR) skills play a pivotal role in lowering mortality rates associated with sudden pre-hospital fatalities. In North America and Europe, an alarming annual tally of approximately 700,000 CA-related deaths is documented [3, 4], among whom more than 200,000 fatalities could have been averted through timely resuscitative interventions, including CPR, followed by advanced life support measures. The prognosis for CA depends on the timing of resuscitation and the normalization and correctness of procedures [5, 6].

For BLS providers, rapid initiation of CPR depends on their ability to swiftly recognize clinical signs, as this reduces the time to CPR initiation [4]. The key factors influencing the success of patient care in BLS include the depth and speed of chest compressions and minimizing interruptions during CPR. Many countries have moved towards standardizing BLS training. However, a survey involving 78 healthcare professionals revealed that only 31.9% of trainees had prior BLS training, although it is recognized that BLS knowledge significantly improves among healthcare professionals after training. Moreover, at Baylor College of Medicine in Texas, USA, medical students achieved compliance with American Heart Association (AHA) compression guidelines in 70% of CPR cycles following BLS training [7, 8]. Nevertheless, the factors affecting BLS knowledge acquisition during training remain unclear.

Hence, a comprehensive analysis of factors impacting the accuracy of BLS knowledge is imperative to enhance CA patients' treatment outcomes, which could pave the way for the development of more effective training or workshop programs aimed at addressing these factors and enhancing the BLS skills of trainees undergoing training.

2. Methods

2.1 Study design

This study comprised 398 trainees who were enrolled in standardized residency training at West China Hospital of Sichuan University in 2022 (Fig. 1). They were from different medical schools or hospitals and had received systematic training in basic life support skills over a 3-day period. The training tasks for all participants were conducted by the same teacher, and at the end of the training, we conducted an online closed-book examination using the WeChat App for assessment. Two trainers evaluated the trainees' examination papers, and if there was a large gap between the scores of the two trainers, a third trainer was called for validation of the scores.

2.2 Inclusion and exclusion criteria

The study inclusion criteria were: (1) Trainees enrolled in the Class of 2022 residency training at West China Hospital of Sichuan University. (2) Recently graduated medical professionals with a medical background. (3) Willingness to participate in the study after providing informed consent. The exclusion criteria were as follows: (1) Trainees who did not attend the Basic Life Support (BLS) training. (2) Trainees who declined to participate in the study after attending the BLS training.

2.3 Teaching methods

In this study, two primary teaching methods were used by the trainers. The first method involved a theoretical explanation followed by practical exercises, in which the trainer initially provided a comprehensive theoretical overview of BLS, followed by a practical demonstration of BLS procedures on a model. The second method entailed practice while watching instructional videos. Then, in a designated demonstration room, the trainer showed BLS teaching videos to the trainees to observe and subsequently perform live BLS procedures based on the video guidance.

2.4 Definition of test results

For the second part of the participants' assessment, consisting of 20 questions, the researcher assigned different grades based on the scores. Specifically, a knowledge score of 60 or above was categorized as "pass", and was used to calculate the pass rate. A score of 81 or above was defined as "excellent", and this category was used for analyzing the excellent rate. Scores of 60 or below were considered "fail", indicating the need for further training. These data were kept confidential throughout the study.

2.5 Sample size calculation

To determine the sample size, the Contingency Table (Chi-Square Tests) was used in the PASS v15.0 software (NCSS, LLC, Kaysville, Utah, USA). Accounting for an acceptable error rate of 5%, a design effect and cluster effect of 1.0, and a test efficacy of 80%, we estimated a sample size of 341 participants with a 95% confidence interval (CI). To accommodate potential non-responses from some participants, 10% of the estimated sample size was added, resulting in a final sample size of 374 participants.

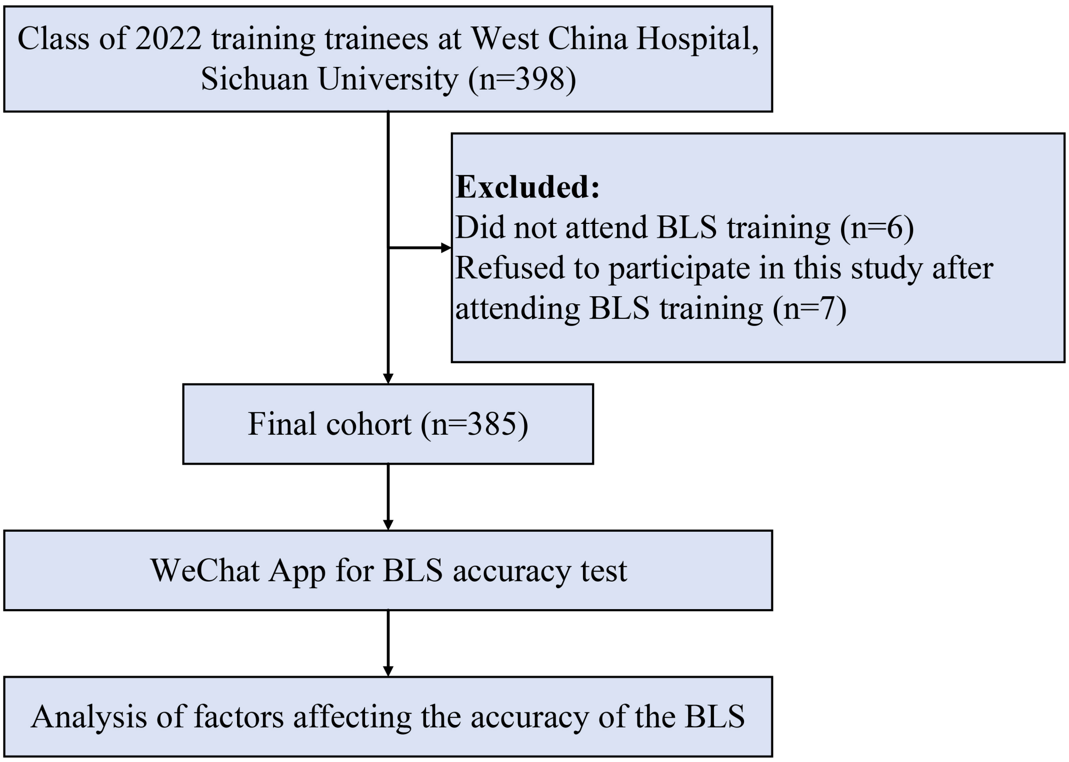

FIGURE 1. Flow chart of the study. BLS: Basic life support.

2.6 WeChat App and data collection

The WeChat App, developed by Tencent in China, is a widely utilized messaging platform among the Chinese population, offering features for sharing pictures and files, as well as voice and video calls. For this study, the WeChat App on mobile phones was used to design and distribute the BLS examination questionnaire to the participants, which consisted of two main sections. The first section gathered information on social factors, including age, gender, educational background, professional title and previous training experience. The second section focused on BLS in CPR and included a total of 20 questions, comprising 15 multiple-choice, 3 fill-in-the-blank, and 2 short-answer questions. Each correct answer had a score of 5 points, with a maximum achievable score of 100 points. Before starting the examination, all participants were seated in a spaced-out classroom and were instructed to independently complete the exam within 60 minutes and submit their responses *via* the WeChat app on their mobile phones. Then, their examination paper was evaluated by two teachers, and the final grade was categorized as follows: Fail (<60), Pass (60–80) and Excellent (>80), based on the total score obtained.

2.7 Study outcomes

This study used the pass rate (≥60 points) of the trainees after BLS training as the primary outcome. The secondary outcome was factors affecting the quality of BLS training.

2.8 Statistical analysis

Data were assessed using GraphPad Prism 9.0 (GraphPad Software Inc., San Diego, CA, USA) and SPSS 26.0 (SPSS Inc., Chicago, IL, USA). BLS accuracy was tested for normality using the Shapiro-Wilk (SW) test. As the data did not follow a normal distribution, descriptive statistics, including median (M) and interquartile range (Q25, Q75), were used. Non-parametric tests, specifically the Kruskal-Wallis H test or Mann-Whitney U test, were applied to compare groups. Statistical information was expressed in rates (%). Linear regression analysis was employed to investigate the factors influencing BLS accuracy. A significance level of $p < 0.05$ was considered as the threshold for statistical significance.

3. Results

3.1 Baseline characteristics of trainees

A total of 385 standardized trainees participated in this study, of whom 258 (67.01%) were female and 127 (32.99%) were male. Most participants were within the 20–25 age group (67.79%), followed by 26–30 years (24.42%), 31–40 years (6.75%), and 41–50 years (1.04%). In addition, the analysis indicated that 94.55% of the trainees were junior, 220 (57.14%) were doctors, 135 (35.06%) were technicians, 24 (6.23%) were pharmacists and 4 (1.04%) were nurses. Among the trainees, 213 (55.32%) had received previous BLS training and 172 (44.68%) had not received any BLS training, and most of the trainees (75.32%) preferred the "theoretical lecture followed by practical exercises" teaching method (Table 1).

TABLE 1. Basic characteristics of resident trainees.

Characteristics	n	%
Age		
20–25	261	67.79%
26–30	94	24.42%
31–40	26	6.75%
41–50	4	1.04%
Gender		
Female	258	67.01%
Male	127	32.99%
Educational background		
Junior college	29	7.53%
Undergraduate	257	66.75%
Master's degree	96	24.94%
Doctor	3	0.78%
Working years		
0–1	307	79.74%
2–3	40	10.39%
4–5	14	3.64%
>6	24	6.23%
Professional title		
Primary	364	94.55%
Intermediate	18	4.68%
Auxiliary height	2	0.52%
Positive height	1	0.26%
Profession type		
Doctor	220	57.14%
Technician	135	35.06%
Pharmacist	24	6.23%
Nurse	4	1.04%
Others	2	0.52%
Prior BLS participation		
No	172	44.68%
Yes	213	55.32%
Teaching style preference		
First theoretical explanation after practical operation	290	75.32%
Practice while watching videos	95	24.68%
Training time (day)		
1	13	3.37%
2	48	12.47%
3	324	84.16%

BLS: Basic life support.

3.2 Factors influencing BLS accuracy and comparison of results

The overall mean correct rate among all 385 standardized students was 64.91%, demonstrating a median correct rate (interquartile range) of 65% (50%–80%). Individual student scores ranged from 10% to 100%. Of the participants, 260 students successfully passed the examination, resulting in a pass rate of 67.53%, and 32 students achieved distinctions, representing an 8.32% distinction rate. The accuracy of students' BLS scores through analysis of variance showed no significant differences based on age, gender, education, years of experience, professional title or teaching style preference. However, significant differences were observed in terms of profession type ($F = 39.45$, $p < 0.001$) and prior BLS training attendance ($t = -4.42$, $p < 0.001$) (Table 2). Pairwise comparisons revealed that doctors exhibited significantly higher accuracy rates compared to technicians ($Z = 5.875$, $p < 0.001$) (Fig. 2).

3.3 Relationship between social factors and BLS test scores

Participants were categorized into three groups based on their examination results: failed, passed and passed with honors. The statistical outcomes are presented in Table 3, from which it can be seen that age, profession type, and prior BLS training were factors impacting the examination results. In the group of trainees who achieved honors, most were young physicians, predominantly within the same profession type, and most had prior BLS training experience. Thus, a trainee's profession type and previous BLS training were considered the primary determinants influencing BLS knowledge acquisition and BLS procedure performance accuracy. Based on these findings, it can be deduced that increasing the frequency of BLS training sessions could be an effective strategy to achieve our training objectives.

3.4 Effect of profession type and training on BLS accuracy

To identify the factors affecting the accuracy of the BLS, we conducted linear regression analysis using the accuracy of BLS scores as the dependent variable and significant factors (profession type and previous training experience) as the independent variables. The results showed that the accuracy of BLS scores was 12% lower for technicians compared to physicians ($\beta = -0.12$, $p < 0.001$), and the accuracy was 8% higher for those who had participated in similar training compared to those who had not ($\beta = 0.08$, $p < 0.001$) (Table 4).

4. Discussion

This present study identified key factors influencing the acquisition of BLS knowledge among residency trainees, with profession type and prior BLS training being the primary determinants, highlighting the importance of proactive engagement

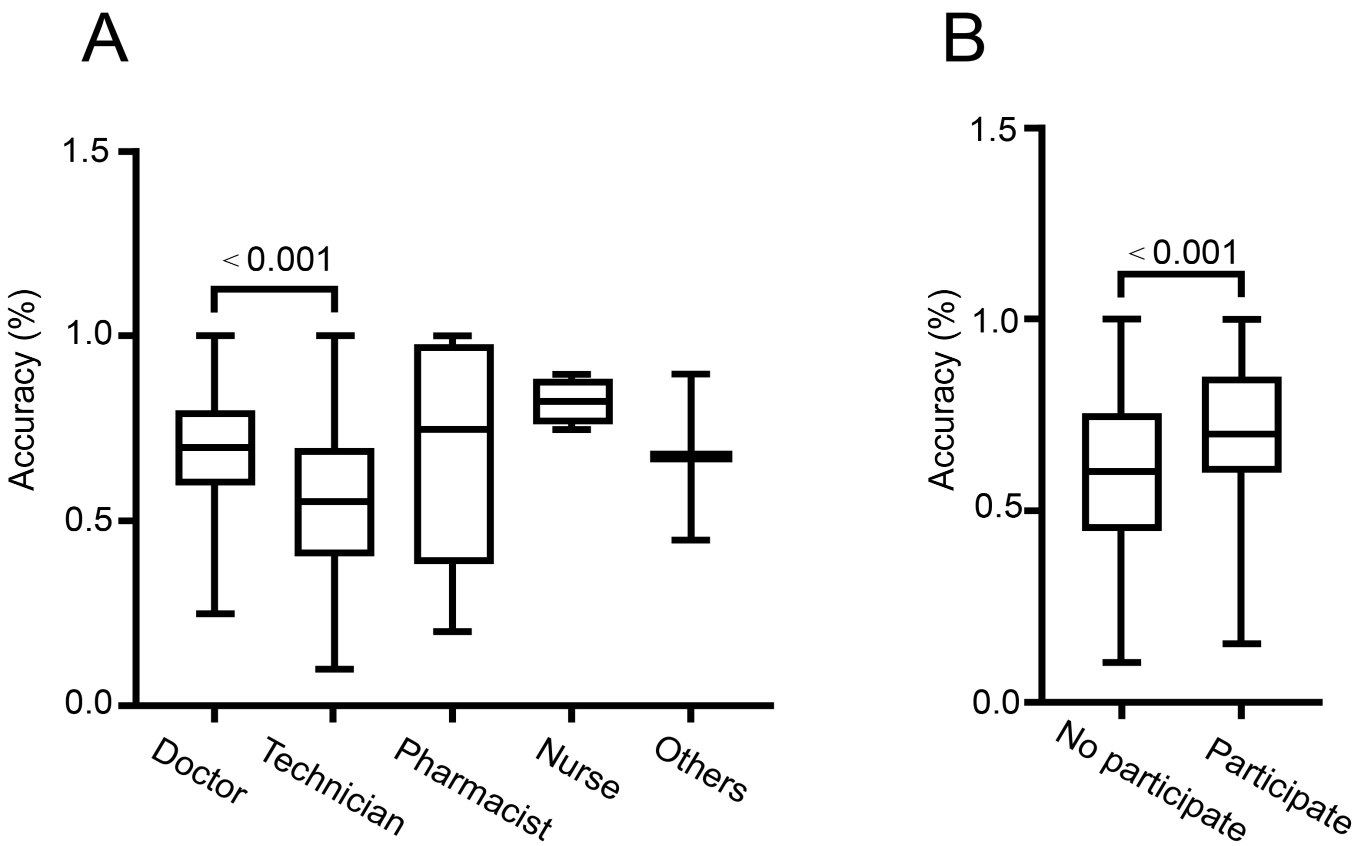

FIGURE 2. Differences in the accuracy of BLS knowledge. (A) Comparison of personnel based on profession. (B) Comparison of trainees with and without previous BLS training.

TABLE 2. Univariate analysis of factors affecting BLS knowledge acquisition.

Characteristics	Median (Q25–Q75)	H/U	*p*
Age			
20–25	65% (50%–85%)	4.85	0.181
26–30	65% (50%–70%)		
31–40	75% (60%–80%)		
41–50	73% (55%–80%)		
Gender			
Female	65% (50%–80%)	−0.10	0.920
Male	65% (50%–80%)		
Educational background			
Junior college	65% (50%–85%)	0.23	0.972
Undergraduate	65% (60%–80%)		
Master's degree	65% (55%–75%)		
Doctor	65% (40%–90%)		
Working years			
0–1	65% (50%–80%)	3.45	0.331
2–3	70% (50%–83%)		
4–5	73% (65%–80%)		
>6	73% (55%–80%)		
Professional title			
Primary	65% (50%–80%)	2.66	0.452
Intermediate	75% (55%–80%)		
Auxiliary height	55% (45%–65%)		
Positive height	80% (80%–80%)		
Profession type			
Doctor	70% (60%–80%)	39.45	<0.001
Technician	55% (40%–70%)		
Pharmacist	75% (43%–98%)		
Nurse	83% (77%–88%)		
Others	67% (45%–90%)		
Prior BLS participation			
No	60% (45%–75%)	−4.42	<0.001
Yes	70% (65%–85%)		
Teaching style preference			
First theoretical explanation after practical operation	65% (50%–80%)	0.60	0.550
Practice while watching videos	65% (45%–75%)		
Training time (day)			
1	70% (62%–81%)	3.15	0.393
2	67% (51%–80%)		
3	77% (45%–97%)		

BLS: Basic life support.

TABLE 3. Comparison of social factors in test score groupings.

Variables	Failed the examination (n = 15)	Passed the examination (n = 323)	Passed the examination with honors (n = 47)	*p*
Age, n (%)				
20–25	3 (20.0)	232 (71.8)	26 (55.3)	<0.001
26–30	10 (66.7)	80 (24.8)	4 (8.5)	
31–40	2 (13.3)	11 (3.4)	13 (27.7)	
41–50	0 (0)	0 (0)	4 (8.5)	
Gender, n (%)				
Female	9 (60.0)	222 (68.7)	27 (57.4)	0.258
Male	6 (40.0)	101 (31.3)	20 (42.6)	
Educational background, n (%)				
Junior college	2 (13.3)	25 (7.7)	2 (4.3)	0.067
Undergraduate	6 (40.0)	217 (67.2)	34 (72.3)	
Master's degree	6 (40.0)	79 (24.5)	11 (23.4)	
Doctor	1 (6.7)	2 (0.6)	0 (0)	
Working years, n (%)				
0–1	11 (73.3)	266 (82.4)	30 (63.8)	0.082
2–3	2 (13.3)	31 (9.6)	7 (14.9)	
4–5	1 (6.7)	10 (3.1)	3 (6.4)	
>6	1 (6.7)	16 (5.0)	7 (14.9)	
Professional title, n (%)				
Primary	14 (93.3)	306 (94.7)	44 (93.6)	0.982
Intermediate	1 (6.7)	14 (4.3)	3 (6.4)	
Auxiliary height	0 (0)	2 (0.6)	0 (0)	
Positive height	0 (0)	1 (0.3)	0 (0)	
Profession type, n (%)				
Doctor	5 (33.3)	171 (52.9)	44 (93.6)	<0.001
Technician	8 (53.3)	126 (39.0)	1 (2.1)	
Pharmacist	1 (6.7)	23 (7.1)	0 (0)	
Nurse	1 (6.7)	1 (0.3)	2 (4.3)	
Others	0 (0)	2 (0.6)	0 (0)	
Prior BLS participation, n (%)				
No	9 (60.0)	150 (46.4)	13 (27.7)	0.026
Yes	6 (40.0)	173 (53.6)	34 (72.3)	
Teaching style preference, n (%)				
First theoretical explanation after practical operation	10 (66.7)	250 (77.4)	30 (63.8)	0.096
Practice while watching videos	5 (33.3)	73 (22.6)	17 (36.2)	

BLS: Basic life support.

TABLE 4. Linear regression analysis of the variability in the acquisition of BLS knowledge by trainees in different profession types.

Factors	β	SE	*t*	*p*	95% CI
Profession type (with doctors as reference)					
Technician	−0.12	0.02	−5.63	<0.001	−0.16, −0.08
Pharmacist	0.02	0.04	0.55	0.584	−0.06, 0.10
Nurse	0.16	0.09	1.73	0.085	−0.02, 0.35
Others	−0.01	0.13	−0.06	0.953	−0.27, 0.25
Have participated before (not participated without reference)	0.08	0.02	3.94	<0.001	0.04, 0.12
Constant term	0.64	0.02	35.37	<0.001	0.61, 0.68

CI: confidence interval; SE: standard error.

by technical staff in BLS training initiatives. Furthermore, conducting multiple BLS training sessions was found to be advantageous for enhancing trainees' knowledge and comprehension of BLS principles. Thus, we recommend for professional organizations to organize systematic training sessions for the general public to improve the success rate of out-of-hospital cardiac arrests.

Cardiac arrest ranks among the leading causes of death, frequently occurring in critical healthcare settings with elevated mortality risks [9, 10]. According to World Health Organization (WHO) guidelines, timely and effective resuscitation within 3–5 minutes of cardiac arrest significantly enhances survival rates and reduces disability [10]. Proficiency in BLS knowledge and skills plays a pivotal role in saving the lives of individuals who experience sudden collapse, placing an increased demand on medical staff to possess adequate knowledge and competencies to deliver standardized BLS care [10]. Notably, in our study, the majority of the trainers were female (67.01%). A similar trend was observed in an Indian study examining healthcare workers' familiarity with CPR knowledge and skills [11]. Nevertheless, our current study's results demonstrated no significant gender-based disparities in BLS knowledge accuracy.

In this study, more than half of the trainees had a bachelor degree (257 (66.75%)), followed by master's degree holders (96 (24.94%)), college degree holders (29 (7.53%)), and doctoral degree holders (3 (0.78%)). Using educational attainment as the independent variable, our study showed that there was no correlation between the accuracy of BLS knowledge and educational attainment, similar to researchers in Nepal who investigated the BLS knowledge of health care workers [11, 12]. Regarding work experience, our study revealed that the majority, 79.74%, had 0–1 year of experience, followed by 10.39% with 2–3 years, 6.23% with more than 6 years, and 3.64% with 4–5 years of experience. However, no significant differences were observed in the accuracy of BLS knowledge based on years of work experience.

Furthermore, our study revealed no significant difference in BLS knowledge accuracy based on the preference for teaching methods, whether it was "theoretical lectures followed by practical exercises" or "watching videos while performing". In a systematic review, variations were noted in the level of knowledge among healthcare professionals following BLS training. One study [13] reported improvements in healthcare professionals' knowledge after training, irrespective of the training method employed, which contrasts with our findings. This disparity might be primarily attributed to the lack of a comparison of different teaching methods in the cited study, highlighting an area for future improvement. Additionally, no study has examined whether the instructional abilities of different instructors impact BLS knowledge accuracy.

In a systematic review addressing teaching methods for disseminating CPR knowledge within specific settings [13, 14], it was observed that effective BLS teaching should not solely focus on providing CPR knowledge but should also strive to enhance student initiative. Another study [14] evaluated the efficacy of teaching medical staff and found that blended learning and interactive approaches significantly improved knowledge, clinical skills and accuracy compared to traditional teaching models. Given the high turnover rate of medical staff, hospitals and educational institutions should continue offer BLS training programs regardless of the teaching method to ensure the timely reinforcement of BLS knowledge and skills. Short-duration basic teaching courses have proven effective in this regard. For instance, our study revealed that 213 (55.32%) trainers had previously received BLS training, while 172 (44.68%) had not, and we observed a significant correlation between BLS knowledge accuracy and prior training, similar to previous studies. Studies have shown [15, 16] that annual 50-minute training sessions can help maintain BLS accuracy, while a short rolling 4-month refresher proved to be more effective. Therefore, we recommend a short rolling refresher of BLS training in schools and hospitals.

Since 2010, the focus of BLS has been on providing high quality CPR services to professional rescuers. However, the low knowledge of BLS among health professionals such hospital nursing staff, technicians, pharmacists and community medical assistants remains an issue that needs improvement [17]. This aligns with our study's findings, which demonstrated that physicians exhibited significantly more accurate BLS knowledge compared to technicians, paramedics or pharmacists. Regarding strategies to enhance lay BLS knowledge, recent CPR guidelines highlight the necessity of adopting a multi-system perspective, emphasizing the concept that "systems save lives". This approach underscores the interconnectedness of communities and society, emphasizing the role of strengthening community-based emergency medical services to enhance cardiac arrest outcomes. Notably, strategies aimed at improving communication and collaboration between lay emergency responders and the professional resuscitation system represent a crucial avenue for saving more lives and empowering lay individuals to perform self-treatment in emergency situations. In alignment with our study, other research [18, 19] has shown that 56.9% of medical graduates possessed good knowledge of basic life support, with 94% having received training in basic life support, advanced life support and exposure to populations requiring basic life support. These factors were significantly correlated with a strong grasp of basic life support, consistent with our study's findings.

Improving the standard of care for also reflects the increasing demand for healthcare professionals to possess greater precision in their BLS knowledge and skills. The latest American Heart Association guidelines [20, 21] recommend that a CPR team leader be assigned to the CPR rescue team to help assist the facility's CPR team in delivering high quality CPR, which includes collaborating with the medical team leader to coordinate the initiation of CPR, providing guidance on achieving greater frequency and depth in chest compressions, facilitating effective communication among team members, and providing real-time audio-visual feedback from equipment monitoring ventilation-pressure ratios, ventilation rates, compression depth, recoil force and rates to promote the highest possible quality of CPR. Also, the guidelines [22] recommend conducting a formal debriefing after CPR, involving two or more medical rescuers, to enhance the efficiency of rescue operations by allowing a comprehensive review of its initiation, progress and conclusion and offering a platform for discussing the rationale behind various key interventions and identifying strategies for future improvement. It is important to recognize that BLS is intricately intertwined with advanced life support and post-acute care, encompassing the physical and psychological evaluation of patients and their families, extending from the end of the acute treatment phase to their rehabilitation upon discharge. Rehabilitation usually necessitates the support of a specialized healthcare system, encompassing physical recovery, mental health assessment and the planning of post-discharge rehabilitation [19].

Our study has several limitations. Firstly, we had a relatively small sample size limited to students in medicine and related disciplines, potentially limiting the generalizability of our results to the broader population. Further investigation of BLS knowledge accuracy among residents is needed. Secondly, our study is primarily descriptive, and it differs from other research that assesses the impact of teaching methods on BLS knowledge accuracy. Thirdly, our study included mainly clinicians and technicians, with fewer pharmacists and nurses, which could introduce bias into the results. Additionally, the teaching model was standardized across all trainers, and the absence of a standardized control group could have affected the study outcomes. These limitations could be addressed in future research through randomized controlled trials that incorporate different training methods in various healthcare settings, schools, and multiple centers.

5. Conclusions

Profession type and previous participation in BLS training were the main factors influencing BLS knowledge acquisition. Considering these findings in conjunction with previous training experiences, we recommend the implementation of rotational training encompassing essential skills like basic life support and cardiopulmonary resuscitation in future studies. Furthermore, the utilization of diverse training methods within randomized controlled clinical trials involving various populations could enhance the authenticity and reliability of study outcomes.

AVAILABILITY OF DATA AND MATERIALS

The datasets for this manuscript will be made available upon request, further inquiries can be directed to the corresponding author wuyaoyao198612223207@wchscu.cn.

AUTHOR CONTRIBUTIONS

YW and HL—design, drafting, and revision of the paper. YW, PP and EP—data collection and collation. YW and PP—data analysis and manuscript writing. HL—guidance on the research process and revision of the article. All authors contributed to the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures performed in studies involving human participants were performed in accordance with the Declaration of Helsinki and approved by the ethics committee of the West China Hospital of Sichuan University (No. 2022-0493). All participating trainees signed an informed consent form. Data from all trainees were analyzed anonymously.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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