ORIGINAL ARTICLE

Knowledge and Skills in Cardiopulmonary Resuscitation and Effect of Simulation Training on it among Healthcare Workers in a Tertiary Care Center in India

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Abstract

Aim and background: High-quality cardiopulmonary resuscitation (CPR) is associated with improved patient outcomes, but healthcare workers (HCWs) may be frequently undertrained. This study aimed to assess baseline knowledge and skills among HCWs about basic and advanced life support and the effect of simulation-based training on it.

Methods: It was a single-center prospective quasi-interventional study among resident doctors and nurses at a Tertiary Center in New Delhi, India. A questionnaire-based assessment was done to assess baseline knowledge. The participants then underwent simulation-based training followed by questionnaire-based knowledge assessment and skill assessment. A repeat questionnaire-based assessment was done 6 months post-training to assess knowledge retention.

Results: A total of 82 HCWs (54 doctors and 28 nurses) were enrolled. The participants scored 22.28 ± 6.06 out of 35 (63.65%) in the pre-training knowledge assessment, with low scores in post-cardiac arrest care, advanced life support, and defibrillation. After the training, there was a significant rise in scores to 28.32 ± 4.08 out of 35 (80.9%) ($p < 0.01$). The retention of knowledge at 6 months was 68.87% ($p < 0.01$). The participants scored 92.61 ± 4.75% marks in skill assessment with lower scores in chest compressions and team leadership roles. There was a positive correlation ($r = 0.35$) between knowledge and skills scores ($p < 0.01$).

Conclusion: There is a progressive decrease in baseline knowledge of HCWs with the further steps in the adult chain of survival. The simulation training program had a positive impact on the knowledge of HCWs. The training programs should focus on defibrillation, advanced life support, post-cardiac arrest care, and leadership roles.

Keywords: Cardiopulmonary resuscitation, Healthcare workers, Knowledge, Skills training.

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Highlights

- Healthcare workers (HCWs) scored lower in chest compressions and leadership skills.
- Knowledge in post-cardiac arrest care and defibrillation needs improvement.
- Simulation training had a positive impact on the knowledge of cardiopulmonary resuscitation (CPR) in HCWs.

Introduction

Cardiac arrests are an important health issue leading to significant mortality and morbidity. Early initiation of CPR, better quality of chest compressions, and rapid defibrillation have been associated with improved outcomes. However, it has been observed that in-hospital care providers are frequently undertrained in life support techniques contributing to suboptimal patient outcomes.[1] This situation may be of more concern in developing countries due to limited resources and lack of uniform structured teaching and training programs for resuscitation.

Various studies have recognized suboptimal knowledge levels regarding CPR among healthcare professionals.[2–5] While many studies have been conducted among medical students, there is an unmet need for evaluation of HCWs directly engaged in patient care, who are the first responders in cardiac arrests.[6,7] With the

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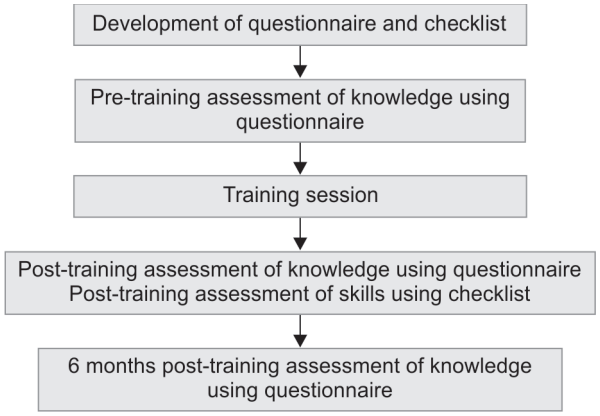

Fig. 1: Workflow of the study

second-largest population in the world, the Indian healthcare system employs a large number of healthcare professionals and caters to a diverse population. However, there is scant data regarding baseline knowledge and skill levels for HCWs in India. Also, ethical issues in learning directly with the patient and time constraints have necessitated simulation-based learning methods. Thus, there is a need to evaluate the impact of such learning methods on the knowledge and skills of HCWs. Also, there is a need to assess the lacunae in specific areas of knowledge and skills of HCWs in which improvement may lead to better patient outcomes.

Thus, the study aimed to assess the baseline knowledge and skills among resident doctors and nurses about basic and advanced life support and the effect of simulation-based training on it. The primary objectives were a questionnaire-based assessment of baseline knowledge and skills about basic and advanced life support, and an assessment of improvement in knowledge by comparing pre-test and post-test questionnaires after simulation-based training. The secondary objective was the assessment of knowledge retention six months after simulation-based training.

Methods

It was a single-center prospective quasi-interventional study conducted among HCWs (resident doctors in the internal medicine residency program and nurses) posted in medical wards at a Tertiary Care Institute in New Delhi, India, between January 2019 and February 2021. A questionnaire-based assessment was done to assess the baseline knowledge of the participants. The participants then underwent simulation-based training followed by questionnaire-based knowledge assessment and skill assessment. A repeat questionnaire-based assessment was then done 6 months post-training to assess residual knowledge (Fig. 1).

The study was approved by the Institute Ethics Committee, All India Institute of Medical Sciences, New Delhi, India (IEC-535/05.10.2018). Written informed consent was obtained from all participants before enrolment in the study. The procedures followed were per the ethical standards of the ethics committee and the Declaration of Helsinki of 1975.

Tools

Development of a Questionnaire to Assess Knowledge and a Checklist to Assess Skills

The questionnaire and checklist were developed to include components of both basic and advanced life support as well as consider practical issues faced in the Indian Healthcare setting.

Source of support: Nil
Conflict of interest: None

This was done through a standard methodology consisting of a literature review, focused group discussions, interviews with experts, item generation, and expert evaluation for content and face validity.[8,9]

An extensive literature review was done, which included major guidelines on resuscitation, including the American Heart Association (AHA), International Liaison Committee on Resuscitation (ILCOR), European Resuscitation Council (ERC) and Indian Resuscitation (IRC), along with the search for relevant articles on the search engines PubMed and Google Scholar.[10–14] Subsequently, focus group discussions and in-depth interviews were conducted with experts and HCWs to gain insight into practical issues faced during CPR as well as key areas to be focused on during training.

A total of 45 items were generated in the questionnaire (to assess knowledge), and 65 items were generated in the checklist (to assess skills). This questionnaire was further evaluated and validated for its content, clarity, and ambiguity by six experts trained and certified in CPR. For content and face validity, experts were asked to comment on the necessity, clarity, and relevance of each item. Based on the expert evaluation and feedback regarding the necessity and relevance of items, 10 items were deleted from the questionnaire. In the questionnaire four items were further modified for better clarity. Similarly, 13 items were deleted, and two items were modified in the checklist. Thus, 35 items were finally retained in the questionnaire for the assessment of knowledge and 52 items were retained in the checklist to assess skills.

The final questionnaire (Appendix A in supplementary material) thus comprised 35 items covering various domains of resuscitation viz. recognition of cardiac arrest, CPR, defibrillation, advanced life support, and post-cardiac arrest care. All the items were scored either 0 or 1, with 1 point being given for the correct response. The final checklist (Appendix B in supplementary material) consisted of 52 items covering scene safety, chest compression, airway, breathing and ventilation, defibrillation, team dynamics, management of arrhythmias, and post-cardiac arrest care. Each item was scored 0 or 1 based on the performance of the skill by the participant.

Intervention

Training Sessions

Based on the literature review, focused group discussions, and interviews, a schedule for training the HCWs was devised to cover important aspects of basic and advanced life support training. The training workshop consisted of a series of training sessions including lectures and skill stations covering various areas of CPR over approximately 7 hours, considering the limited resources, time, and manpower available in the developing countries (Appendix C in supplementary material). Each training session involved an expert teaching important concepts to the participants, followed by a discussion through case-based scenarios. Skill stations consisted of a demonstration of proper technique on the mannikins by the expert followed by practice of technique by participants in different case-based scenarios. All sessions were moderated by experts trained and certified in CPR.

Data Collection

The questionnaire to assess the baseline knowledge of the participants was administered at the start of the workshop.

Table 1: Overall knowledge score of participants at baseline before training, after training and after 6 months

	Scores				*p-value*		
Domain (number of questions)	*Pre-training*	*Post-training*	*6 months*	*Retention*	*Pre vs post-training*	*Post-training vs 6 month*	*Pre-training vs 6 month*
Total score (35)	22.28 ± 6.06	28.32 ± 4.08	26.44 ± 3.96	68.87%	<0.01	<0.01	<0.01
Recognition and activation (5)	4 (3–4)	4.5 (4–5)	4 (3.75–5)	53.25%	<0.01	0.03	<0.01
CPR (13)	9.06 ± 3.01	11.66 ± 1.84	10.66 ± 1.90	61.54%	<0.01	<0.01	<0.01
Defibrillation (3)	2 (1–2)	2 (2–3)	2 (2–3)	78.57%	<0.01	0.35	0.11
Advanced life support (10)	5.71 ± 1.97	6.93 ± 1.90	6.89 ± 1.45	96.72%	<0.01	1.00	<0.01
Post-cardiac arrest care (4)	2 (1–3)	3 (3–4)	3 (2–4)	71.57%	<0.01	<0.01	0.02

At the end of the workshop, the skills of participants in case-based scenarios were assessed using the checklist for the same. The questionnaire was also administered again at the end of the training session to assess the post-training knowledge of the participants.

The questionnaire was administered again after 6 months of training sessions to assess the retention of knowledge of the participants. The administration of questionnaires and assessment of skills were done under direct observation to ensure completeness and accuracy of data collection.

Sample Size

The baseline knowledge regarding CPR in various studies ranged 38–72% and it increased to 63–98% after training.[1] Considering baseline knowledge score of 63.97% (25.58 ± 5.6 out of 40 marks) and improvement of scores to 84.74% (33.88 ± 3.38 out of 40 marks) after training as observed in a study in a similar population, the estimated sample sizes for the assessing primary outcomes with 5% relative precision and 95% confidence interval were 74 for the baseline knowledge and 6 for the improvement in knowledge.[15] Thus, a sample size of 74 was chosen for the study.

Statistical Analysis

The data was entered and coded in the Excel sheet and analyzed using STATA 16.0 (College Station, Texas, USA) and IBM SPSS Statistics 26. The continuous variables were reported as mean and standard deviation or median and interquartile range as appropriate, while categorical variables were reported as frequency and percentages. Student *t*-test or Wilcoxon rank-sum test was used for testing significance in continuous variables, while the Chi-square test was used for categorical variables. For variables following normal distribution, the change in values over time within the group was evaluated by repeated measure ANOVA followed by multiple comparisons using paired *t*-test with Bonferroni correction. On the other hand, in the case of non-parametric data, the change within the groups over time was assessed by the Friedman test, followed by multiple comparisons using the signed-rank test with Bonferroni correction The retention of knowledge was calculated based on the relative change in knowledge scores at 6 months compared to those at baseline and post-workshop. Two-tailed *p*-value < 0.05 was considered statistically significant.

Results

In this study, 82 HCWs (54 resident doctors in the postgraduate training program and 28 nurses) posted in the medical wards were enrolled. A total of seven training workshops were conducted, with 10–14 participants in each workshop.

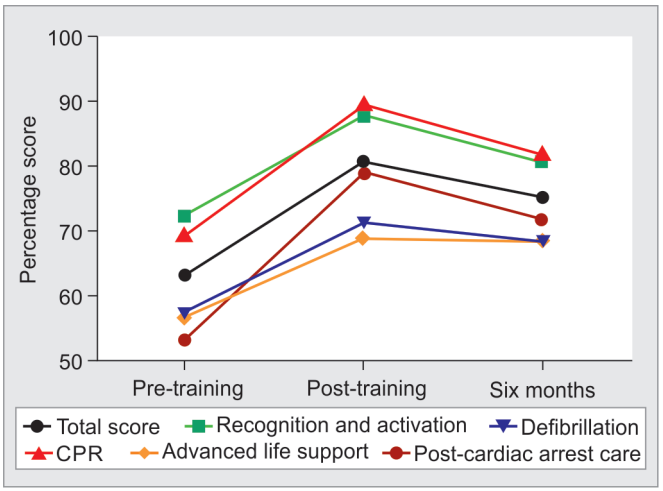

Fig. 2: The knowledge score of the participants in various domains before training, after training, and 6 months after the training workshop

Baseline Knowledge

The participants achieved a mean score of 22.28 ± 6.06 out of 35 (63.65%) in the pre-workshop assessment (Table 1). The participants scored highest in the domains of recognition and activation of emergency medical response system (EMS) and CPR, while they scored least in post-cardiac arrest care, advanced life support, and defibrillation.

Change Over Time

The participants scored 28.32 ± 4.08 out of 35 (80.9%) in the assessment taken after the workshop. They scored highest again in recognition and activation of the EMS and CPR, while they scored less in defibrillation and advanced life support. A statistically significant positive change was observed in all the domains of resuscitation compared to the pre-test. The highest improvement was observed in the domain of post-cardiac arrest care (Fig. 2).

After 6 months, the participants scored 26.44 ± 3.96 (75.54%) in the follow-up assessment. Though it had decreased compared to the post-workshop score, the total score was still significantly higher than the pre-workshop score (*p*-value < 0.01). The participants scored highest in the domains of CPR and recognition and activation of EMS, while they scored less in defibrillation and advanced life support. The follow-up score was significantly higher in most domains compared to the pre-workshop assessment, with the highest improvement being noted in post-cardiac arrest care.

The retention of knowledge at 6 months was approximately 68.87% and was highest in the domain of advanced life support, followed by defibrillation and post-cardiac arrest care.

Table 2: Change in knowledge scores over time in subgroups: Residents and nurse

	Scores				p-value		
Domain (number of questions)	*Pre-training*	*Post-training*	*6 months*	*Retention*	*Pre vs post-training*	*Post-training vs 6 month*	*Pre-training vs 6 month*
Residents							
Total score (35)	24.13 ± 5.74	29.81 ± 3.71	27.50 ± 3.44	59.33%	<0.01	<0.01	<0.01
Recognition and activation (5)	4 (3–5)	5 (4–5)	4 (3–5)	25.45%	<0.01	<0.01	0.16
CPR (13)	9.89 ± 2.79	12.11 ± 1.66	10.98 ± 1.72	49.10%	<0.01	<0.01	0.01
Defibrillation (3)	2 (1.75–2.25)	2 (2–3)	2 (2–3)	71.02%	<0.01	0.26	0.048
Advanced life support (10)	6.30 ± 1.88	7.44 ± 1.89	7.30 ± 1.19	87.72%	<0.01	1.00	0.01
Post-cardiac arrest care (4)	2 (1–3)	3 (3–4)	3 (2–4)	75.98%	<0.01	0.12	<0.01
Nurses							
Total score (35)	18.71 ± 5.04	25.43 ± 3.13	24.39 ± 4.15	84.52%	<0.01	0.632	<0.01
Recognition and activation (5)	3 (3–4)	4 (4–5)	4 (4–5)	95.84%	<0.01	0.92	<0.01
CPR (13)	7.46 ± 2.81	10.79 ± 1.89	10.04 ± 2.10	77.48%	<0.01	0.32	<0.01
Defibrillation (3)	2 (1–2)	2 (1–2)	2 (1–2)	99.81%	0.09	0.94	0.11
Advanced life support (10)	4.57 ± 1.62	5.93 ± 1.51	5.90 ± 1.60	97.78%	0.01	1.00	0.01
Post-cardiac arrest care (4)	2 (1–2)	3 (2.25–4)	3 (2–3)	63.37%	<0.01	0.08	<0.01

Table 3: Skills of the participants

Domain	*Total (n = 82)*	*Nurses (28)*	*Residents (54)*	*p-value*
Total score (52)	92.61 ± 4.75	89.29 ± 3.64	94.34 ± 4.35	<0.01
Scene safety (2)	95.12 ± 16.87	94.64 ± 15.75	95.37 ± 17.56	0.85
Check for responsiveness (3)	89.84 ± 20.75	80.95 ± 26.34	94.44 ± 15.53	<0.01
High-quality chest compressions (6)	89.02 ± 14.40	85.12 ± 12.29	91.05 ± 15.09	0.07
Breath/Ventilation (6)	92.89 ± 11.12	91.67 ± 11.56	93.52 ± 10.94	0.48
AED/Defibrillator (6)	92.07 ± 10.55	88.10 ± 10.98	94.14 ± 9.78	0.01
Team leader (3)	89.43 ± 18.80	88.10 ± 18.62	90.12 ± 19.02	0.64
Tachycardia management (5)	90.73 ± 11.84	84.29 ± 13.72	94.07 ± 9.22	<0.01
Bradycardia management (2)	96.34 ± 13.10	92.86 ± 17.82	98.15 ± 9.53	0.08
Ventricular fibrillation management (6)	95.73 ± 8.20	92.86 ± 8.40	97.22 ± 7.76	0.08
PEA management (4)	93.29 ± 13.06	86.61 ± 17.32	96.76 ± 8.48	<0.01
Post-cardiac arrest care (3)	93.50 ± 13.06	90.48 ± 17.82	95.06 ± 13.59	0.19
Airway (6)	92.48 ± 12.87	95.83 ± 9.76	90.74 ± 13.99	0.08

Subgroup Analysis of Resident Doctors and Nurses

Residents scored 24.13 ± 5.74 out of 35 (68.94%) in the pre-workshop test, which improved to 85.17% in the post-workshop test and 78.57% at 6 months follow-up (Table 2). They scored highest in recognition and activation of EMS and CPR, while they scored less in post-cardiac arrest care and defibrillation. There was a statistically significant increase in knowledge scores in most domains compared to the pre-workshop test. The retention of knowledge at 6 months was 59.33%, with the highest being in the domain of advanced life support.

Nurses scored 18.71 ± 5.04 out of 35 (53.45%) in the pre-test, which improved to 72.65% in the post-test and to 69.68% at 6 months follow-up. The nurses scored highest in recognition and activation of EMS, while they scored least in advanced life support and post-cardiac arrest care. There was a statistically significant increase in knowledge scores in all domains except defibrillation compared to the pre-workshop test (Table 2). There was a retention of 84.52% with a non-significant decrease in scores at 6 months follow-up compared to the post-workshop test.

Residents had a significantly higher total score on all the tests compared to nurses (p-value < 0.05). The residents also scored significantly higher in individual domains of CPR and advanced life support in all the tests. The retention was higher in nurses compared to residents at 6 months of follow-up (84.52 vs 59.33%; Table 2).

Skills

The participants scored 92.61 ± 4.75% marks in the assessment of skills (Table 3). They scored highest in scene safety, bradycardia, and ventricular fibrillation management, while lower scores were obtained in domains of high-quality chest compression, checking for responsiveness, tachycardia management and team leadership role.

Residents scored significantly higher marks than nurses (94.34 ± 4.35 vs 89.29 ± 3.64; p-value < 0.01). They significantly scored higher in checking for responsiveness, defibrillation, and management of tachycardia, and pulseless electrical activity (PEA), while nurses scored higher in airway management.

Table 4: Correlation between skills and knowledge

Domain of knowledge	*Correlation coefficient*	*p-value*
Total	0.35	<0.01
Recognition and activation	0.19	0.09
Chest compressions	0.11	0.34
Defibrillation	–0.09	0.43
Advanced life support	0.13	0.25
Post-cardiac arrest care	0.05	0.67

Correlation between Knowledge and Skills

There was a statistically significant positive correlation (r = 0.35) between total scores on knowledge and skills in post-test assessments ($p < 0.01$) though no statistically significant correlation was observed between scores in individual domains (Table 4).

Discussion

The baseline knowledge level among resident doctors and nurses (63.65%) in this study suggests that there has been considerable improvement in the level of knowledge and skills in areas where resuscitation training has been introduced, compared to the last century.[1,15–17] The baseline knowledge in the present study was comparable to another study from Central India as well as those conducted in other parts of the world.[2,15,18] Still, many studies observe suboptimal knowledge or confidence regarding resuscitation among HCWs in different parts of the world, viz. Ethiopia, Nepal, New Zealand, Sweden, and Denmark.[2–4,19,20] The competence is worse in areas where there are no formal programs for CPR training.[5,21] The participants scored highest in the domains of recognition and activation of EMS and CPR repeatedly. This may be explained by the frequent application of knowledge in the above two domains during patient care and the frequent stress on it in the medical curriculum. Though post-cardiac arrest care has been associated with improved survival with favorable neurological outcomes, the participants scored the least in post-cardiac arrest care.[22] This highlights an important lacuna in the knowledge of HCWs, which merits emphasis during training.

In this study, there was a statistically significant improvement in the knowledge of the participants after the workshop. The highest improvement was observed in the domain of post-cardiac arrest care, in which the participants scored the least in pre-assessment. This reflects the effectiveness of the training workshop. The participants scored less in areas of defibrillation and advanced life support, which has also been observed in other studies where only 20% of doctors felt confident in defibrillation.[2] This is of significant concern and highlights the need for more training sessions on defibrillation among HCWs.

Studies have observed that simulation-based interventions and enhanced content delivery have the greatest impact on retention.[23] A significant retention of knowledge at 6 months post-workshop (59.33%) in resident doctors may indicate the long-lasting impact of such training programs. The domains in which participants scored the least at six months were the same as those immediately after assessment (viz. advanced life support and defibrillation). This highlights the need for re-oriented stress on domains in which scores are low during the follow-up training sessions.

The assessment of skills revealed that high-quality chest compressions, checking for responsiveness, tachycardia management, and leadership roles merit further improvement. Other studies have also highlighted poor performance in leadership roles and a lack of confidence among doctors in defibrillation.[2,3] The use of CPR feedback devices and simulation training has been observed to be significantly better for the acquisition of resuscitation skills.[24,25] Thus, the use of simulation training and CPR feedback devices especially for chest compressions, and greater emphasis on leadership roles and defibrillation during training are recommended.

Better knowledge leads to a better attitude toward CPR performance in HCWs.[26] But there is scant data regarding the correlation of knowledge with skills.[16] In this study, there is a significant correlation between the total scores of knowledge and skills of participants. Though this could be explained by the inclusion of skill stations along with training sessions in the workshop, this significant correlation may also suggest that higher knowledge may transform into better skills which may lead to better patient outcomes.[27]

Resident doctors scored higher in both knowledge and skills compared to nurses, which is consistent with studies from developing countries in contrast to similar studies in developed countries.[3,28] This may be attributable to the practice that residents are more involved in direct patient care compared to nurses in developing countries. Nurses had higher retention of knowledge at the end of 6 months with a non-significant decrease in total scores at 6 months compared to post-test scores. They also scored higher in advanced life support at 6 months compared to the post-training assessment. Though this is consistent with the observations that those with lower scores retain more knowledge after CPR training, the higher retention among nurses, especially in the domain of advanced life support, could also be explained by the two additional training sessions on resuscitation received by the nurses after the workshop as part of their institutional routine training program.[1]

The strength of the study is that this is one of the few studies done on HCWs who are directly involved in patient care. It also evaluated both the knowledge and skills of the participants after the workshop to assess the correlation between them. It also helped in identifying specific domains which need to be improved in further training programs. The limitations of the study include the inability to collect data on baseline skills and those at 6 months which limits the ability to determine the impact of training workshops on skills and their retention, and the absence of validated cut-off scores to assess the competency of the participants. Also, future studies should incorporate objective outcome measures that would indicate a meaningful improvement in clinical behavior or patient outcomes (like an increase in rates of return of spontaneous circulation after intervention). Although the validity of the questionnaire and the checklist were established qualitatively, the quantitative assessment of the same would have been better. Besides, the additional training sessions attended by nurses affected the analysis of long-term retention of their knowledge at 6 months.

Conclusion

There is a significant disparity in baseline knowledge of HCWs with the further steps in the adult chain of survival. The simulation training program had a positive impact on the knowledge of doctors and nurses. Future training programs should focus on defibrillation, advanced life support, post-cardiac arrest care, and

leadership roles, and periodic training programs may be of benefit to maintain the enhancement in quality of resuscitation.

Supplementary Materials

All the supplementary materials are available online on the website of www.ijccm.org.

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