EFFECTIVENESS OF ONLINE WEBINARS AS A LEARNING TOOL IN PARAMEDICAL EDUCATION: A PRE- AND POST-ASSESSMENT STUDY

***Dr. Ashwini Dhananjay Ookalkar [1],Ashwini Kidney Trust,** Nagpur, India ,

Prof. Rajshree Vaishnav[2], Professor and Head PG Dept. of Education, RTMNU, Nagpur,
Dr. Suresh Ughade [3], Ex - Faculty, Community Medicine Dept, Govt.Medical College, Nagpur,
Dr. Dhananjay S. Ookalkar[4] , Ashwini Kidney Trust, Nagpur, India ,

*** Corresponding author**

Abstract

Background: Infections, particularly bloodstream infections, are a leading cause of morbidity and the second leading cause of mortality in hemodialysis patients. Continuous training in infection control is crucial for dialysis paramedical staff (technicians, nurses, and related professionals) to prevent healthcare-associated infections. The COVID-19 pandemic accelerates the adoption of webinar-based and asynchronous e-learning for medical and allied health education. This study evaluates the effectiveness of an online webinar teaching intervention on infection control knowledge among paramedical dialysis staff. **Methods:** A one-group pre-test/post-test design is used. Dialysis paramedical staff (n=57) from various centers participated in a structured infection control webinar. Participants completed a 20-item multiple-choice knowledge test before (pre-test) and after (post-test) the webinar. Demographics and prior training data are collected. The intervention comprises a live interactive webinar covering standard precautions, dialysis-specific infection prevention practices, and case discussions, supplemented by downloadable resources for asynchronous review. Improvement in test scores is analyzed with paired statistics. **Results**: Participants have a mean age of 35.6 years with 65% female. Baseline infection control knowledge is moderate (pre-test mean score 12.7 out of 20). After the webinar, scores improved significantly (post-test mean 17.5; paired $t = 10.83$, $p < 0.001$), with 86% improving their score. **Conclusion:** Webinar-based training markedly enhances infection control knowledge among dialysis paramedical staff. This finding supports webinars as an effective, flexible educational modality for continuing education in infection prevention.

Keywords: *Webinar-based learning, virtual classroom teaching, Paramedical education, e-learning, Asynchronous teaching.*

1. INTRODUCTION

Globally, healthcare professionals are tasked to provide high-quality patient- and community-centered care for improved health outcomes. In the current fast-paced and ever-changing healthcare landscape, staying abreast of the latest medical advancements and best practices is

essential in meeting patients' needs. The rapid evolution of healthcare demands continuous learning, particularly in paramedical professions. The purpose of the continued growth of healthcare is to provide an e-learning environment and an opportunity to enhance the knowledge and skills of healthcare professionals. Webinars are one of the digital technological tools for learning. The use of webinars has gained a lot of attention in recent years. Thus, webinars offer a flexible and interactive platform for education (Boutros et al., 2023; Aryee et al., 2024). (Ebner & Gegenfurtner, 2019) defines webinars as "A seminar that happens online over the Internet rather than offline in a traditional classroom." They further define it as "web-based seminars, in which students and teachers are connected, live across distant geographical locations using shared virtual platforms and interact synchronously in realtime via voice over IP and web camera equipment". (Stebbings et al., 2020) stated that the Webinars reportedly strengthened students' social presence whilst enhancing learning through the 'Zone of Proximal Development', where students developed their learning and understanding from interactions with knowledgeable others.

Among the digital tools and infrastructures for training, webinars are commonly applied in distance education and blended learning training programs. Trainees and trainers report that they are satisfied with or enjoy participating in webinar-based training (Gegenfurtner et al., 2020). These studies (Carrick et al., 2017; Ebner & Gegenfurtner, 2019) evaluate training effectiveness and are examples of using quantitative methodology to estimate and examine the extent to which webinar-based training environments develop trainee knowledge and skills. According to (Goudarzi et al., 2024), the online/combined courses showed better academic outcomes than the face-to-face course in the preclinical clerkship. The educational outcome was examined by implementing subjective and objective assessments of medical students during their preclinical clerkship. Therefore, the development of online/combined courses in the medical school curriculum during this period was seen as promising. Further, [8] summarized the effectiveness of Virtual Reality (VR) training in teaching donning and doffing of Personal Protective Equipment (PPE) to prospective healthcare practitioners. According to the findings, VR and face-to-face training significantly outperformed and were superior to video training. Participants in the video group demonstrated significantly less accuracy in glove removal, hand hygiene, gown removal, and gown roll-up.

The literature suggests that when thoughtfully implemented, webinar-based education is an effective and acceptable approach for continuing the education of healthcare professionals, including in critical areas like infection control. There is evidence of significant knowledge gain, high satisfaction (especially regarding flexibility), and equivalence to traditional training in many cases. (Masoud et al., 2021). A virtual approach was found useful to facilitate training of health department staff in rural areas for COVID related training (Penna et al., 2022). Nonetheless, challenges, such as confirming practical skills competence and overcoming technical limitations are recognised. This study adds to the literature by providing specific data on knowledge improvement in a cohort of dialysis paramedical staff who experienced webinar training on infection control. It builds on prior work by focusing on a specialized group and topic and integrating the analysis's quantitative outcome (test score improvement) and participant profile. Additionally, the research evaluates the effectiveness of webinar-based online teaching in enhancing infection control knowledge among paramedical dialysis staff.

Objectives of the study

i. To assess the baseline knowledge of infection control practices among dialysis paramedical staff using a structured pre-test.

ii. To deliver a structured online webinar on infection control protocols relevant to dialysis settings.

iii. To compare the pre-test and post-test knowledge scores to determine the effectiveness of the webinar-based teaching intervention.

iv. To analyze the shift in knowledge levels (e.g., from poor to moderate or excellent) across predefined performance categories.

v. To examine the relationship between participant characteristics (e.g., experience, prior training, and workplace setting) and knowledge gained post-webinar.

vi. To contribute to the evidence base for using virtual classrooms and asynchronous teaching methods in paramedical education.

2. METHODOLOGY

2.1 Study Design

A one-group pre-test/post-test quasi-experimental design is adopted to evaluate the effectiveness of webinar-based teaching. The research flow is presented in Figure 1. Initially, participants completed a pre-test to assess their baseline knowledge. An online webinar session as an educational intervention followed this. Subsequently, a post-test, mirroring the content of the pre-test, is administered to measure knowledge gain. Due to logistical limitations, the control group is not included; each participant serves as their control, enabling within-subject comparison of pre-and post-intervention performance.

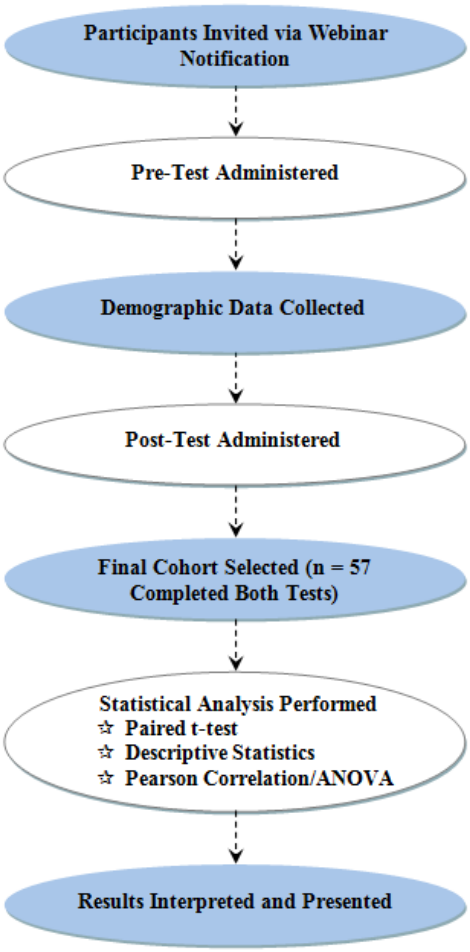

Figure 1: Flowchart of the research design and process. The study involves a baseline knowledge assessment, a live webinar training intervention on infection control, and a follow-up assessment to measure knowledge improvement.

2.2 Participants

The study population is comprised of paramedical staff involved in dialysis care, including dialysis technicians and nurses. Participants are recruited from various dialysis centers through an invitation to attend an infection control webinar. A total of 155 individuals complete the pre-test; 106 participates in the webinar and submits the post-test. For analysis, attention is restricted to the 57 participants who complete both pre-and post-tests, forming the matched cohort for evaluating knowledge change. Demographic characteristics are obtained via an online questionnaire combined into the pre-test form.

Key demographics were as follows:

- **Age:** Participants range from 21 to 58 years (mean ≈ 35.6, SD ≈ 8.1). A majority (70%) are in their 20s or 30s.
- **Gender:** 37 participants (65%) are female and 20 (35%) male.

- **Professional Role:** The group includes dialysis technicians (about 28%), dialysis nurses (approximately 25%, including various titles, such as staff nurse), and individuals who identify as "dialysis professionals" or similar designations (around 42%). One participant is a student intern. This indicates a mix of frontline dialysis staff roles.

- **Experience:** Experience in dialysis care varies: 23% have <2 years, 33% have 2–4 years, 30% have 4–8 years, and 12% have over 8 years of experience. Thus, most are early-career or mid-career professionals.

- **Work Setting:** 58% work in private dialysis centers, 37% in government hospitals, and a small remainder in corporate or charitable hospitals.

- **Prior Training:** When asking about prior infection control training, only 19 participants (33%) report having any certification in infection control, while 38 (67%) do not. Regular staff training frequency also varies: the most common response is "as required" (on-demand training, ~60%), with others reporting scheduled training either monthly (21%), annually (10%), or semi-annually (7%). One individual reports weekly training. This indicates that formal infection control education is not uniform across the cohort, and many rely on infrequent or ad-hoc training.

2.3 Intervention – Webinar Description

The educational intervention is a 90-minute live webinar titled "Infection Control in Dialysis: Best Practices." The webinar is conducted via a video conferencing platform (Zoom) and moderated by an infection control specialist. It incorporates multiple teaching elements: a slideshow presentation, live demonstrations (via video) of proper catheter exit-site dressing and machine disinfection, poll questions to engage the audience, and a Q&A session. Topics covered align with the pre/post-test content and include hand hygiene protocols, use of personal protective equipment, environmental cleaning of dialysis stations, dialyzer reprocessing and disposal, catheter and fistula care, water treatment/disinfection (RO system maintenance), and handling of medications/vials in dialysis units. The webinar is designed to be interactive – participants can answer poll questions (with results shown immediately) and ask questions in chat or orally during the Q&A. The intervention is delivered in a single session.

To accommodate asynchronous learning and reinforcement, the webinar is recorded, and a link is provided to participants afterward along with reference materials (guideline summaries and a checklist for dialysis infection control). While our primary evaluation focuses on the immediate post-webinar knowledge test, providing the recording aims to encourage review and serve those who may have connectivity issues during the live session.

2.4 Assessment Tools

A 25-item questionnaire is developed to capture participant demographics and training background, administered before the webinar. Additionally, a 20-item multiple-choice knowledge test is constructed to assess infection control knowledge in dialysis settings. The

same test is administered both before and after the webinar intervention. Example questions include: *"When should a transparent catheter dressing be changed?"*, *"What step is critical before needling a patient to prevent infection?", "How often should dialyzer reuse effectiveness be checked, and what parameter is measured?"* etc. These questions are formulated based on established guidelines (CDC and dialysis unit protocols). The test is scored out of 20 points (one point per correct answer). The post-test uses the same questions but in a shuffled order to minimize recall bias. Importantly, participants are not given the correct answers in between; they only receive their scores after each test. This approach measures knowledge gained from the webinar itself rather than from answering feedback.

2.5 Data Collection

The pre-test, including consent, demographics, and knowledge quiz, is administered online one day before the webinar via Google Forms. By using a similar form, the post-test is administered online immediately after the webinar (within 1 hour of completion). Each participant's responses are linked via email addresses, which serve as unique identifiers to pair pre and post-scores. Identifiers are coded to ensure data privacy and compliance, and de-identified data is analyzed. The study invitation and form include an informed consent statement and voluntary participation. No incentives are provided beyond a certificate of participation in the educational event.

2.6 Data Analysis

At first, a descriptive analysis of participant demographics and pre-test knowledge levels is analyzed. Each participant's pre-test and post-test scores are paired for the main outcome. A paired *t*-test (two-tailed) has been used to evaluate the statistical significance of the mean score improvement. A significance level of $\alpha = 0.05$ is set *a priori*. The individual score changes are calculated, and participants are categorized based on whether their scores improved, remained unchanged, or declined. Additionally, secondary analyses include (a) computing the percentage of participants answering each question correctly pre vs. post (to identify which content areas improve the most) and (b) examining whether certain demographic factors (like experience or certification) correlate with pre-test scores or with the degree of improvement (using Pearson correlation or one-way ANOVA as appropriate). Results are primarily presented as aggregate improvements.

2.7 Ethical Considerations

This study is conducted as part of an educational quality improvement initiative. Participants are informed that the quiz data are used to evaluate the effectiveness of the training. No personal health information is involved. Anonymized results are used, and no individual performance is reported to employers. If this study is under IRB oversight, then it will likely qualify for exempt status as an educational research study without identifiable private information. Nonetheless, this study adheres to the ethical principles of confidentiality and voluntary participation.

3. RESULT AND DISCUSSION

3.1 Participant Profile and Pre-Webinar Knowledge

A total of 57 participants completed both the pre-and post-test (as noted). They represent a diverse group of dialysis paramedical personnel from different institutions. Table 1 summarizes the key demographic and background characteristics of this cohort:

Table 1: Demographics and background of the study participants (dialysis paramedical staff completing pre- and post-tests)

Character istic	**Participants (N=57)**
Mean Age	35.6 years (SD 8.1), range 21–58 years
Gender	37 Female (65%); 20 Male (35%)
Primary Role	~42% Dialysis Technologists/"Professionals"; ~25% Nurses; ~28% Technicians; ~5% Other (incl. 1 student)
Years of Dialysis Experience	0–2 years: 13 (23%); 2–4 years: 19 (33%); 4–8 years: 17 (30%); 8+ years: 7 (12%)
Current Workplace	33 Private centers (58%); 21 Government hospitals (37%); 3 Others (5%)
Infection Control Certification	19 Yes (33%); 38 No (67%)
Frequency of Prior Training	"As required" (on demand): 34 (60%); Monthly: 12 (21%); Semi-annually: 4 (7%); Annually: 6 (10%); Weekly: 1 (2%)

****Note***: "Dialysis Professional" was a self-chosen designation by some participants indicating a dialysis healthcare provider without specifying nurse/tech; these were grouped with technicians for analysis. Percentages may not sum to 100 due to rounding.

Before the webinar, participants' baseline knowledge showed room for improvement. The mean pre-test score was 12.7 (SD 3.3) out of 20 (64% correct on average). The median was 13, and scores ranged from 4 (minimum) to 20 (maximum). Only two individuals (3.5%) achieved a full score of 20/20 on the pre-test, indicating that even experienced staff had gaps in certain areas. Common weak regions of the pre-test included the proper handling of multi-dose medication vials (only 8% knew vials shouldn't be shared between patients), the correct timing for replacing dialysis station disinfectant solution, and steps for reuse of dialyzers (many missed the need for thorough flushing to remove clots). These specific knowledge gaps align with known, challenging areas in dialysis infection control – e.g., medication handling often deviates from recommended practice in busy units. On a positive note, participants widely knew some basics. For example, over 90% correctly answered that a

disinfection cycle on machines should be performed after each session, reflecting that certain protocols are well ingrained.

3.2 Knowledge Improvement After Webinar

After the webinar intervention, knowledge scores increased markedly. The mean post-test score rose to 17.53 (SD 3.3) out of 20, equivalent to 87.5% correct. The median post-test score was 19. This represents an average gain of +4.74 points (+23.7 percentage points) per participant. Figure 2 illustrates the difference in mean scores before and after the training.

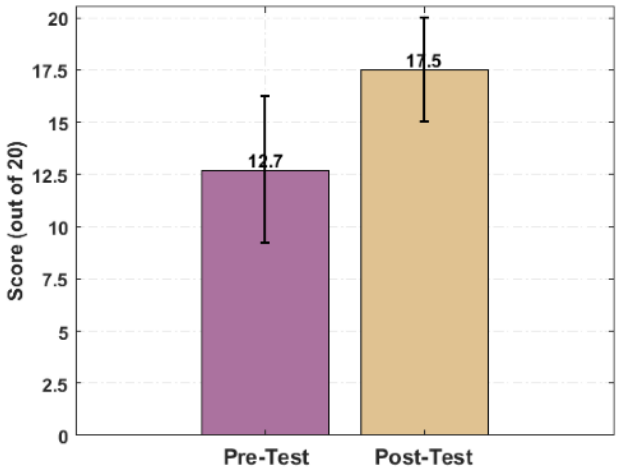

Figure 2: Mean knowledge scores before and after the webinar (with standard deviation error bars). The post-webinar mean score was significantly higher ($p<0.001$) than the pre-webinar mean.

Table 1. Calculation of 't' Value for Pre-test and Post-test

Test	Number of samples	Mean	S.D.	Calculated 't' value
Pre-test	57	12.76	2.8	5.3936*
Post-test	57	17.53	3.3	

*Significant at 0.01 level of significance

The mean value of the post-test was found to be greater than the mean value of pre-test of group which infers that there is difference between the mean achievement scores of the students before and after teaching through online webinar. The calculated value of 't' was 5.3936 which is significant at 0.01 level of significance

Thus it is inferred that there is a significant difference between the mean of pre-test and post-test scores indicating that the webinar had a measurable positive effect on the participants' knowledge. Out of 57 participants, 49 (86%) improved their test scores, 6 (11%) had no change (scoring the same pre- and post-test), and only 2 individuals (3%) scored lower on the post-test than the pre-test. Those two had minor declines (dropping by 1 point each) – potentially due to momentary lapses or guessing differences, as no participant had a substantial post-test drop. Participants scoring 100% jumped from 2 pre-webinar to 26 post-webinar (3.5% to 45.6%). In other words, nearly half the group answered all 20 questions

correctly after the training, indicating that the webinar effectively conveyed the critical information.

Figure 3 shows the score distribution pre- and post-webinar to visualise the distributional changes. Before training, scores were somewhat spread out (many in the 10–15 range, with only a few above 18). After training, the distribution shifts dramatically to the right – a large cluster of participants scored 18, 19, or 20 on the post-test, and very few scored below 12.

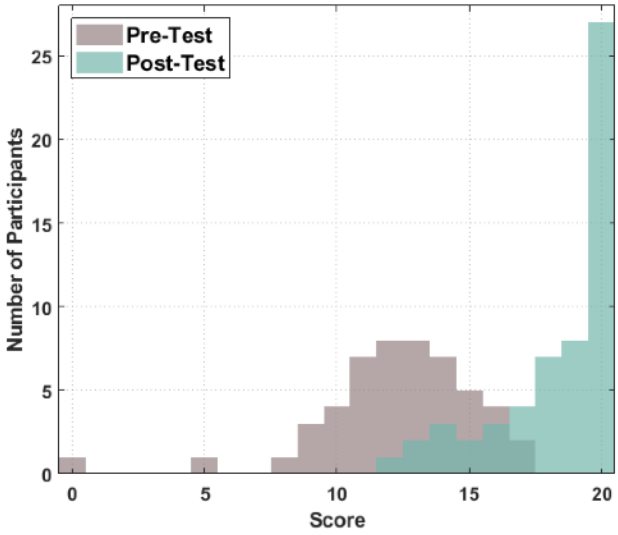

Figure 3: Distribution of pre-test and post-test scores. Blue bars = number of participants at each score on pre-test; Green bars = post-test. The post-test distribution is skewed toward higher scores, indicating overall knowledge gain among participants.

Breaking down performance by content area provides further insight. Participants showed the most improvement on dialyzer reuse and disinfection protocol questions. For example, on a question asking *"What is a critical step during the reuse of dialyzers"* – focusing on proper flushing to remove blood clots. 85% answered correctly post-webinar compared to ~50% pre-webinar. Many participants initially lacked knowledge of this specialized topic, but the webinar's segment was on dialyzer reprocessing (which emphasized thorough flushing and disinfection concentration checks). Another big jump was seen in the question on multi-dose medication vials. In the pre-test, only 8% knew that separate vials should be used for each patient (a majority selected incorrect options like disposing after one use or, worryingly, sharing among patients). After the webinar's emphasis that multi-dose vials must never be shared and ideally should be dedicated per patient with an impressive 88%. This ~80% improvement suggests strong effectiveness in correcting a dangerous misconception.

Similarly, knowledge about the frequency of changing transparent dressings on catheter exits improved (post 100% got the right answer: "change at least weekly or if soiled," up from ~70% pre). Questions on hand hygiene steps and personal protective equipment were already well-answered pre-webinar (reflecting baseline familiarity) and remained high post-webinar (little room for improvement). One challenging area was the recommended contact time for disinfectants in the water distribution loop (an advanced topic) – only about 60% got it right even after training (up from 30% pre). This indicates that highly technical details may

need reinforcement beyond a single session. Overall, every question saw an increase in correct responses post-training. The knowledge gains were broad, covering both routine practices and specific protocols.

The large overall improvement in scores aligns with findings from similar training evaluations. Our observed knowledge gain (+23.7 percentage points on average) is comparable to the improvements reported in other studies of infection control education. For instance, a study of nurses' infection control practices by (Singh et al., 2023) noted significant pre-post gains after a training workshop, though measured via practice checklists rather than a test. In our study, the controlled test setting strengthens the evidence that the webinar caused the improvement, as external factors between pre-and post were minimal (the test was taken just after the webinar).

3.3 Effectiveness of Webinar Format

The results strongly suggest that the webinar format effectively delivered the infection control content to the paramedical staff. Several factors likely contributed to this success:

- **Interactive Content:** The webinar did more than lecture and included polls and Q&A. For example, when the instructor polled, "How often do you change catheter dressings in your unit?" and discussed the answers, it actively engaged participants. Such interaction has improved attention and retention in online learning (Elshami et al., 2021). Participants could immediately clarify doubts (some asked questions about dialyzer reprocessing protocol during the session). This interactivity mirrors traditional classroom engagement, crucial for understanding applied topics.

- **Relevance and Context:** The training was tailored to dialysis settings using scenarios familiar to the learners (like "Patient X with a catheter – how do we prevent infection?"). This relevance likely enhanced learning. As (Aryee et al., 2024) noted, content relevance to daily practice is critical for e-learning success. Feedback from participants (through informal comments in chat) indicated they found the examples relatable, which likely aided in knowledge transfer to the test questions.

- **Baseline Motivation:** Given that attendees opted into a webinar outside their routine schedule, assuming they were motivated to learn is reasonable. Many may have recognized their knowledge gaps (as seen in the average pre-test score of ~64%). Motivation can significantly impact outcomes in online learning; motivated learners engage more and thus learn more (Chaker et al., 2024). The high post-test scores might partially reflect this positive selection. In other words, those who stayed through the webinar and completed the post-test were genuinely interested in improving their infection control understanding.

- **Addressing Prior Gaps:** The webinar explicitly targeted areas of deficiency noted in the pre-test. For instance, seeing the low pre-test correct rate on the multi-dose vial question (we checked pre-test results immediately after the pre-test via the form responses), the instructor made sure to hammer on that point during training. This adaptive teaching likely helped correct specific misconceptions. This approach

resembles a formative assessment feedback loop, which is known to enhance learning outcomes by focusing on weaknesses.

It is also worth discussing the few cases of no improvement or decline. Six participants had no change in score. Most had very high pre-test scores (e.g., 18/20 pre- and post). Essentially, they were already near-ceiling and remained so. The two slight declines (one went from 16 to 15, another 14 to 13) are minor and could be attributed to fatigue or misreading a question on the post-test. Given the overall pattern, these do not detract from the webinar's efficacy. On the contrary, maintaining high performance or small variations are expected in any educational setting. It's possible that those individuals answered a hard question correctly by guesswork in the pre-test and then changed their answer in the post-test or lost focus momentarily. No participant indicated technical issues during the post-test, so we can fairly attribute the scores to actual knowledge or attention at that moment.

3.4 Comparison with Literature

Our findings reinforce the literature that online webinars can significantly improve knowledge among healthcare staff. The near-doubling of perfect scores and substantial mean increase mirror the results of other studies where structured e-learning led to large gains in test performance (Penna et al., 2022). This improvement occurred in a practical, safety-critical domain like infection control, not just theoretical knowledge. This suggests that even content traditionally taught through hands-on workshops can be effectively covered via webinars, at least at the cognitive level of understanding. However, it's crucial to acknowledge that *knowledge* improvement, while necessary, may not directly translate into *behavior* change on the dialysis floor without additional reinforcement. Infection control is an area where knowing and doing can differ. For example, one can understand that gloves must be changed between patients, yet fail to do so consistently due to habit or workload. The webinar and post-test evaluated knowledge and an assessment of practice (e.g., audits of vascular access technique) would be needed to confirm changes in behavior. (Singh et al., 2023) found improved practices after training, which was promising. In our context, a follow-up observational study could ascertain whether multi-dose vial handling or catheter site care improved in participants' workplaces following the webinar.

Nonetheless, bridging the knowledge gap is the first step in changing practice. Our participants now overwhelmingly know the correct practices (as evidenced by post-test scores). This creates a foundation for improving compliance. Many guidelines highlight regular staff education as a key component of infection prevention programs. Our study demonstrates that a webinar is an effective method to deliver such education. Particularly for widely dispersed teams or when in-person training is impractical, webinars can ensure that everyone receives a standardized update. This is highly relevant, as remote learning and virtual meetings remain common. It's also useful to consider participant feedback (though formally gathering satisfaction data was beyond our study's scope). Informally, through the webinar chat and emails, several participants expressed that they found the session helpful and appreciated the convenience of attending from their workplace/home. Some noted they would like more frequent such sessions ("maybe a monthly refresher webinar"). This anecdotal evidence of satisfaction is in line with reported high satisfaction rates in studies of webinar-based CME (Gharib et al., 2024). However, some attendees mentioned technical

difficulties (e.g., audio lag) during the live session and those who experienced issues likely benefited from the recorded video provided later. This underlines that while webinars eliminate travel and scheduling barriers, they require reliable tech infrastructure – a point echoed by multiple studies where internet connectivity emerged as a major challenge in online learning (Chandrasiri & Weerakoon, 2022). Our cohort and content were specific to dialysis, but the positive outcomes contribute to the broader understanding that webinar-based training can be a powerful tool in healthcare education. In contexts beyond dialysis, similar improvements have been observed. For instance, a series of webinars for ENT surgeons during COVID-19 improved knowledge test scores significantly and was rated highly by participants (Masoud et al., 2021). Thus, the modality's effectiveness likely extends across various specialties, provided the content is well-designed.

4. CONCLUSION

This study examined the effectiveness of an online webinar as a learning tool for paramedical students. The study proved that webinars are a cost-effective and impactful tool for delivering paramedical education. By bridging geographical barriers and providing flexible learning opportunities, webinars can be critical in skill enhancement and professional development in the healthcare sector. Upon rectifying technical glitches and providing accessible technology, webinars could prove to be a satisfactory aid for the healthcare sector. Thus, webinars have become an inevitable tool in the teaching-learning process among healthcare professionals for further curriculum development and career enhancement. The study findings can help the instructors to conduct more effective webinars. Additionally, educators and makers need technical and operational improvements to address the problems associated with e-learning and their platforms.

Limitations and Future Directions

There are some shortcomings in this study. This research study is limited to the responses of selected professionals. However, the conclusions and discussions are based on their experience. Next, this study assessed short-term knowledge improvement, and long-term retention of information was not evaluated. Future research directions are the systematic research needed to authenticate that learners are actually obtaining skills delivered through webinars and that webinars are the best way to learn conveniently. In addition, future research should also explore standardized metrics for evaluating the effectiveness of webinars and compare outcomes across different healthcare professions and regions.

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