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Effectiveness of a Multimodal Educational Program in Increasing Understanding and Utilization of Tele-ICU Resources by Critical Care Nurses: A Pilot Study

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By

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Abstract

Background. Integration of tele-intensive care units (tele-ICUs) into healthcare systems is associated with improved patient outcomes and organizational performance. Inadequate bedside nurses' knowledge about tele-ICU is associated with poor communication and lack of trust between bedside and tele-ICU teams. These problems might diminish tele-ICU's ability to maximally impact patient outcomes.

Purpose. The purpose of this project was to create a multimodal educational program with the goal of improving knowledge, attitudes, and skills related to tele-ICU among critical care nurses and to assess the effect of the educational intervention on tele-ICU utilization among bedside nurses as evidenced by the number of eLerts initiated at the bedside.

Methods. The study combined a quasi-experimental one group pretest-posttest method with retrospective review of the institutional data. A two-part educational intervention about tele-ICU (lecture, followed by a shadowing experience) was created by the tele-ICU team and presented to 23 Cardiovascular Intensive Care Unit nurses (91.3% never worked with tele-ICU before). The level of nursing knowledge was assessed by a five-question multiple choice survey, and nursing attitudes were assessed utilizing a 10-item survey scored on a 5-point Likert scale. The perceived value of the shadowing experience was assessed by a 5-item survey scored on a 5-point Likert scale. Categorical data were analyzed using frequency distribution. Paired sample t-test and independent sample t-test were used to analyze the changes in knowledge and attitude scores. The median number of eLerts in the three months after the intervention was compared to the median number of eLerts in the same three months of the previous year.

Results. The first part of the intervention resulted in an increase in both knowledge (57.4% [SD 25.1] to 85.2% [SD 19.3], $p<0.001$) and attitude (3.7 [SD 0.6] to 4.4 [SD 0.4], $p<0.001$)

scores. The second part of the educational intervention did not influence the knowledge scores but resulted in an additional increase in the attitude score (4.2 [SD 0.4] to 4.5 [SD 0.4], $p<0.001$). The mean score for the perceived value of the shadowing was 4.8 (SD 0.3). The median number of eLerts did not increase significantly (72 vs 74).

Conclusion. This project supports a combination of lecture and shadowing experience as an effective intervention to improve nursing knowledge and attitudes related to tele-ICU. At the same time, the study highlights two important areas for additional research: 1) relative effectiveness of various educational methods in increasing tele-ICU understanding and skills, and 2) how knowledge and skills are translated into tele-ICU utilization.

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Background and Significance

Since the implementation of the first tele-intensive care unit (tele-ICU) in the year 2000, the technology behind these units has continued to evolve (Udeh et al., 2018). It now includes two-way audiovisual communication between ICU rooms and a tele-ICU center, access to telemetry and electronic health records, as well as specialized software that has built-in patient risk stratification and decision support for clinicians (Udeh et al., 2018). In the last twenty years, multiple benefits of well-integrated tele-ICUs have been documented, including improved patient outcomes and organizational performance (Becker et al., 2019; Deslich & Coustasse, 2014; Udeh et al., 2018).

In January of 2020, University of Kentucky HealthCare (UKHC) partnered with Royal Philips to open the first tele-ICU in the state (Willett & Perry, 2020). In the tele-ICU at UKHC, six registered nurses with multiple years of ICU experience in different areas and one physician monitor patients in all ICUs at Chandler and Good Samaritan hospitals, ready to assist the bedside team at any time. The staff at the tele-ICU at UKHC is capable of managing up to 193 ICU beds, working simultaneously with dozens of bedside RNs and multiple provider teams (Willett & Perry, 2020). The staff at the tele-ICU can communicate with the members of the bedside team through phone calls, secure messaging available throughout the UKHC, or by connecting directly to a patient's room via two-way audiovisual communication. The bedside team members can request tele-ICU presence in any of the ICU rooms by pressing buttons called eLert which are located in every ICU room at Chandler and Good Samaritan hospitals. These buttons send notifications to tele-ICU staff that their assistance is needed by the bedside team. While the tele-ICU staff at UKHC are involved in patient care to some extent, nurses in the

tele-ICU (eRNs) have expressed a concern that the bedside nurses (RNs) lack awareness of all the expertise and technological support tele-ICU has to offer.

Benefits of Tele-ICU

Tele-intensive care units have the potential to influence a variety of patient outcomes (Becker et al., 2020; Becker et al., 2019; Deslich & Coustasse, 2014; Udeh et al., 2018). One significant contribution of tele-ICUs to patient care is increase in best practice compliance with positive effects on such metrics as catheter-associated infections, deep vein thrombosis, and rate of stress ulcer prophylaxis (Becker et al., 2020; Deslich & Coustasse, 2014; Udeh et al., 2018). Also, integration of tele-ICUs has been associated with decrease in medication errors (Deslich & Coustasse, 2014). In addition, enhanced patient monitoring provided by tele-ICUs is associated with increased patient safety, including decrease in falls and self-extubations, earlier identification of patient deteriorations, and decreased response time to critical events (Deslich & Coustasse, 2014; Udeh et al., 2018). Multiple authors reported that integration of tele-ICUs contributes to decreases of up to 1.26 days in ICU length of stay (LOS) and decreased ICU mortality (Becker et al., 2020; Becker et al., 2019; Deslich & Coustasse, 2014; Fusaro et al., 2019; Khurrum et al., 2021; Udeh et al., 2018).

The economic impact of tele-ICUs is difficult to assess due to the complexities of healthcare systems and multiple confounding variables (Ries, 2016). Several authors suggest that the financial benefits of tele-ICUs depend on multiple factors, including characteristics of the patient population, structure of tele-ICU programs, and the level of tele-ICU integration into the healthcare organization (Becker et al., 2019; Lilly & Mickelson, 2019; Udeh et al., 2018). Despite these complexities, three main sources of economic benefits of tele-ICUs can be identified. First, improvements in patient outcomes are associated with financial benefits

stemming from savings when adverse outcomes are prevented, negative events are avoided, and better pay-for-performance metrics are achieved (Becker et al., 2019; Deslich & Coustasse, 2014). Secondly, cost reductions directly related to decreased ICU LOS have been reported (Becker et al., 2019; Deslich & Coustasse, 2014; Khurrum et al., 2021). Finally, optimized bed utilization and increased patient volume associated with tele-ICU implementation have the potential to result in increased revenue (Becker et al., 2019; Khurrum et al., 2021; Lilly at al., 2017). Specific reports of the financial benefits vary widely between organizations. Reported cost reductions range from $5,000 per bed, to $2,150 per patient, to $3 million per year (Coustasse et al., 2014; Deslich & Coustasse, 2014). Lilly et al. (2017) reported an annual direct contribution margin increase of almost $30 million (375.5%) after tele-ICU implementation in one academic medical center.

Kevin Hatton, Division Chief of Anesthesiology Critical Care Medicine at UKHC, described a two-pronged approach to tele-ICU involvement in patient care at UKHC (K. Hatton, personal communication, February 28, 2023). The first idea is to utilize reporting tools built into the tele-ICU software to increase compliance with such best practices as stress ulcer and venous thromboembolism prophylaxis and daily spontaneous breathing trials. The second strategy is to combine tele-ICU alerts and predictive analytics with clinician judgment to implement strategies for early recognition of patient deteriorations and decrease response time to critical events. The goal of these initiatives is to improve patient outcomes and achieve reductions in ICU LOS described in literature (K. Hatton, personal communication, February 28, 2023). Considering high costs of the ICU care, a reduction of ICU LOS buy one day might lead to saving thousands of dollars per patient, depending on their diagnosis and the type of the ICU (Halpern & Pastores, 2015; Self et al., 2019).

Context, Scope, and Consequences of the Problem

A case study by Hoonakker and Carayon (2018) described multiple barriers to optimal tele-ICU utilization from the perspective of tele-ICU nurses, including bedside ICU's staff lack of knowledge about tele-ICU, poor communication with the ICU team, and lack of trust between the teams. Li and Cotton (2019) reported that bedside RNs experience confusion about how to use tele-ICU, discomfort with the sense of "being watched", and mistrust of the technology. These studies suggest that the knowledge barrier perceived by nurses in the tele-ICU at UKHC is not unique to this organization (Hoonakker & Carayon, 2018; Li & Cotton, 2019). Overall, hundreds of clinicians at UKHC might lack awareness of resources and support available through tele-ICU.

The barriers described above can lead to suboptimal communication between tele-ICU and the bedside teams, impede teamwork, and interrupt the workflow (Hoonakker & Carayon, 2018; Li & Cotton, 2019). Studies show that breakdowns in communication between team members are associated with poor outcomes, such as increased length of stay, readmission rates, and costs (Liu et al., 2021; Shoham et al., 2016). Several authors suggested that the degree of collaboration between bedside and tele-ICU teams is directly related to the level of tele-ICU integration into the patient care process and correlates with tele-ICU effects on patient outcomes (Becker et al., 2019; O'Shea et al., 2022). The concerns described by eRNs at UKHC might prevent them from affecting the patient outcomes to the extent tele-ICUs are capable. As a consequence of this, UKHC might not be gaining a full benefit of its tele-ICU.

Current Evidence-based Interventions/Strategies Targeting the Problem

Li and Cotton (2019) suggested that bedside RNs' knowledge and understanding affect acceptance of tele-ICUs. Prior to this project, information about tele-ICU has not been included

into formal nursing orientation at UKHC. This might have been contributing to bedside RNs' inadequate knowledge of tele-ICU resources. While there are no formal guidelines on tele-ICU education for the bedside RNs, a tele-ICU proficiency curriculum may increase nursing knowledge and skills in tele-ICU utilization (Gibson et al., 2021). Gibson et al. (2021) recommended that healthcare organizations develop a formal tele-ICU orientation process for ICU nurses.

Purpose and Objectives

The purpose of this project was to improve understanding and utilization of tele-ICU resources by critical care nurses in the cardiovascular ICU (CVICU) at UKHC. Three specific objectives were pursued: 1) Develop and implement a two-step educational program about tele-ICU for new orientees in CVICU; 2) Design and administer surveys measuring nursing knowledge and attitudes related to tele-ICU before and after each step of the educational intervention and analyze survey results; 3) Conduct an audit of institutional data to determine the effect of the educational intervention on tele-ICU utilization among bedside nurses as evidenced by the number of eLerts initiated in CVICU before and after the educational intervention.

Theoretical Model

A Plan-Do-Study-Act (PDSA) model was selected to guide this project. PDSA is a four-stage cyclical model that allows testing new interventions on a small scale (Christoff, 2018). The cyclical nature of this tool enables organizations to make frequent adjustments to the intervention while testing its benefits and feasibility. This flexibility, combined with small initial impact, made PDSA one of the most frequently utilized models for quality improvement projects in healthcare settings (Christoff, 2018).

According to Christoff (2018), in the first stage of PDSA cycle, called the planning stage, objectives are clearly defined, and the plan for the project design and implementation is developed. After CVICU management reached out to the tele-ICU team with a concern that tele-ICU services are being underutilized by the bedside RNs, tele-ICU representatives met with a group of CVICU RNs to discuss potential barriers. Once knowledge deficit was recognized as one of the potential barriers, the planning stage of this project began with the tele-ICU team working to identify information that needs to be provided to the bedside RNs. A two-part educational intervention consisting of one-hour lecture and a four-hour shadowing experience was created and included in the orientation schedule for the new CVICU employees who started their orientation in the summer of 2022. In addition, pre- and post-intervention surveys were designed, and University of Kentucky Medical Institutional Review Board (UK Medical IRB) approval for this study was obtained.

The second stage of the PDSA model is called “Do” and involves the actual implementation of the project and data collection (Christoff, 2018). In this project, CVICU orientees who participated in the educational modules about tele-ICU were asked to volunteer to complete pre- and post-intervention surveys before and after each part of the intervention. In addition, the monthly number of eLerts initiated in CVICU was obtained from Philips.

The final two stages of the PDSA model, Study and Act, involve analysis of the results and the decision to continue or abandon the intervention (Christoff, 2018). In this project, the results of the pre- and post-surveys were analyzed utilizing SPSS software. In addition, the number of eLerts initiated in the CVICU in the three months after this group of new employees completed the orientation period was compared to the same three months in the previous year.

As a result of this project, the lecture and the shadowing were combined into one four-hour module that became a part of new employee orientation for all ICUs at UKHC.

Review of Literature

A literature search was conducted to support this project's main question: among CVICU RNs, does multimodal educational intervention improve knowledge, attitudes, and skills related to tele-ICU utilization in the immediate post-education period. To find the articles elucidating this topic, PubMed database was searched utilizing the following Boolean phrase: (telemedicine OR tele-ICU OR tele-) AND (nurs*) AND (education OR training). Only articles that contain search terms in the title or the abstract were included. Additional inclusion criteria were: (a) full text article available through the UK library, (b) published in English, and (c) published between 2013 and 2023. This search returned 316 titles that were evaluated for thematic content. The articles discussing patient education, benefits of tele-ICU, use of videoconferencing in clinical training, or other topics not directly related to clinician education about telemedicine were excluded. The bibliography of the included articles was reviewed, and additional articles satisfying inclusion criteria were found.

Review and Synthesis of Evidence

The above search resulted in a selection of twenty-five articles, and their summary is presented in table 1. Two of the studies did not specify the location of the educational program (Chike-Harris, Durham, et al., 2020; Gartz & O'Rourke, 2020). The remaining articles described educational programs developed around the world, including the United States, Canada, Australia, Japan, Brazil, and a number of European countries (Ali et al., 2015; Arends et al., 2021; Burt & Kilroy, 2021; Chike-Harris, Harmon, & van Ravenstein, 2020; Douglas et al., 2018; Edirippulige & Armfield, 2017; Erickson et al., 2015; Fronczek et al., 2017; Gibson et al.,

2021; Gibson et al., 2020; Gustin et al., 2020; Knight & Prettyman, 2020; LaManna et al., 2021; List et al., 2019; Lister et al., 2018; Mennenga et al., 2016; Merritt et al., 2018; Richard et al., 2016; Rutledge et al., 2014; Rutledge et al., 2017; Sapci & Sapci, 2018; Smith et al., 2018; Villegas et al., 2021). Douglas et al. (2018) described an educational program for RNs in an ICU, and Richard et al. (2016) developed education for emergency room personnel. A literature review by Edirippulige & Armfield (2017) summarized studies that described educational interventions for students and/or clinical professionals. The remaining twenty two articles discussed programs for nursing and/or nurse practitioner students at a university setting (Ali et al., 2015; Arends et al., 2021; Burt & Kilroy, 2021; Chike-Harris, Durham, et al., 2020; Chike-Harris, Harmon, & van Ravenstein, 2020; Erickson et al., 2015; Fronczek et al., 2017; Gartz & O'Rourke, 2020; Gibson et al., 2021; Gibson et al., 2020; Gustin et al., 2020; Knight & Prettyman, 2020; LaManna et al., 2021; List et al., 2019; Lister et al., 2018; Mennenga et al., 2016; Merritt et al., 2018; Rutledge et al., 2014; Rutledge et al., 2017; Sapci & Sapci, 2018; Smith et al., 2018; Villegas et al., 2021).

Rutledge et al. (2017) proposed a multimodal framework for telehealth education grouping various teaching methods into four categories: didactics, simulation, clinical experiences, and project-based learning. Eight studies described educational interventions consisting of a single method: didactic (List et al., 2019), simulation (Knight & Prettyman, 2020; Lister et al., 2018; Mennenga et al., 2016; Merritt et al., 2018; Richard et al., 2016; Villegas et al., 2021), or clinical experience (Gibson et al., 2020). All other researchers included methods from two or more categories in their telehealth education approaches. The content areas found in this review ranged from specific skills, such as performing tele-ultrasound (Douglas et al., 2018) or physical assessment via telehealth (Fronczek et al., 2017), to more broad knowledge about

telehealth technologies, including general overview of telehealth, understanding and troubleshooting the technology, telehealth etiquette and interprofessional communication, telehealth-related legislation, and others (Ali et al., 2015; Arends et al., 2021; Gibson et al., 2021; Gustin et al., 2020; Rutledge et al., 2017).

The outcome evaluation criteria varied widely between the articles. While some authors did not specify evaluation methods (Ali et al., 2015; Erickson et al., 2015; Fronczek et al., 2017; Gartz & O'Rourke, 2020; Gibson et al., 2021; Rutledge et al., 2017), others utilized subjective self-assessments of knowledge, skills, and attitude, such as 5-point Likert scale or reflection writing. In all studies, the participants reported that they found the education beneficial and the technology useful. Regardless of the educational and evaluation methods employed by the authors, all authors suggested that telehealth education was associated with increased knowledge, skills, and comfort level as reported by the participants. None of the studies objectively measured participant's knowledge or level of telehealth utilization by the participants.

Summary and Strength of the Evidence

This literature review suggests that a variety of educational methods can be used to increase knowledge and skills related to telehealth technology with multimodal approaches providing the greatest benefit (Gartz & O'Rourke, 2020; Rutledge et al., 2017). However, the level of evidence revealed by this review is relatively low with two non-randomized trials with a sample size of 16 and 225 (Douglas et al., 2018; Richard et al., 2016), seven cohort studies with a sample size from 22 to 206 (Arends et al., 2021; Chike-Harris, Harmon, & van Ravenstein, 2020; Gustin et al., 2020; List et al., 2019; Lister et al., 2018; Mennenga et al., 2016; Sapci & Sapci, 2018), four systematic reviews of descriptive studies (Chike-Harris, Durham, et al., 2020; Edirippulige & Armfield, 2017; Gartz & O'Rourke, 2020; Rutledge et al., 2017), ten descriptive

studies with sample size of N=6 to N=205 (Ali et al., 2015; Burt & Kilroy, 2021; Erickson et al., 2015; Gibson et al., 2020; Knight & Prettyman, 2020; LaManna et al., 2021; Merritt et al., 2018; Rutledge et al., 2014; Smith et al., 2018; Villegas et al., 2021), and one expert opinion (Fronczek et al., 2017; Gibson et al., 2021).

Current gaps and proposal to address them

The review findings are congruent with previously described paucity of literature related to telehealth education (Edirippulige & Armfield, 2017; Rutledge et al., 2017), and the number of articles specific to tele-ICU is especially limited. While a number of authors describe the need for better tele-ICU education of bedside RNs (Gibson et al., 2021; Hoonakker & Carayon, 2018; Li and Cotton, 2019), there is a lack of literature that objectively compares educational methods and quantifies educational outcomes in this area (Chike-Harris, Durham, et al., 2020; Gartz & O'Rourke, 2020; Rutledge et al., 2017). More research is needed to build an effective and efficient tele-ICU curriculum.

Considering the evidence of the effectiveness of multimodal telehealth educational programs in a university setting, this project aimed to develop and implement a multimodal educational pilot program about tele-ICU for bedside RNs. In addition, the project proposed measuring the effects of each module on nursing knowledge and attitudes to evaluate if additional education provides additional benefits. Finally, the project aimed to test if nursing education results in increased tele-ICU utilization.

Methods

Design

The study utilized a prospective, single group, pretest-posttest design combined with retrospective review of the institutional data. The outcome measures examined in this study were

nursing knowledge and attitude related to tele-ICU, nursing perception of the value of the shadowing experience, and the level of tele-ICU utilization as measured by the number of eLerts. This study was approved by the UKHC Nursing Research Council (NRC) and the UK Medical IRB.

Setting

Agency Description

This pilot project was conducted in a CVICU at the UKHC. The CVICU is a 44-bed unit that is located at Chandler hospital. The CVICU serves patients in the immediate post-open heart and thoracic surgery period as well as patients with cardiovascular conditions that require ICU level of care.

Congruence of Project to the Agency's Mission/Goals/Strategic Plan

The mission of the UKHC is to achieve the vision of a healthier Kentucky through DIReCT (Diversity, Innovation, Respect, Compassion, and Teamwork) values (University of Kentucky HealthCare [UKHC], n.d., p. 5). This project is in line with such UKHC values as innovation and teamwork. One of the key objectives outlined in UKHC's Strategic Plan is to "invest in our people", and it includes staff development (p. 11). Another one of the key objectives is to "create a healthier community" (p. 15). Among the strategies for achieving this objective, the "innovative care models" specifically mentions tele-ICU as one of the available tools (UKHC, n.d., p. 15). Since the purpose of this project is to improve understanding and utilization of tele-ICU resources by critical care nurses, it is congruent with UKHC 2025 Strategic Plan.

Description of Stakeholders

Several stakeholders were involved in this project. First, the advisory committee provided guidance and assistance in project development and implementation. The nursing manager of the CVICU was the one who first expressed the need for increased tele-ICU utilization by the CVICU nurses, and he strongly supported this project. The CVICU Education Council worked on including the educational intervention into the orientation schedule of new employees. In addition, the manager and staff of the tele-ICU were enthusiastic to try a new approach to nursing education related to tele-ICU.

Site-Specific Facilitators and Barriers to Implementation

There were several facilitators to this project, including the "buy-in" of nursing managers and higher-level executives overseeing both CVICU and tele-ICU. Another facilitator was the enthusiasm of the tele-ICU staff and management in working towards elimination of knowledge barriers to tele-ICU acceptance. The main barriers to the implementation of this project were nursing shortages and limited orientation time that made inclusion of additional education into the orientation difficult. To minimize the effect of these barriers, special attention was paid to the length of the pre- and post-intervention questionnaires, minimizing nursing time commitment to this project.

Sample

The target population for this study included all ICU RNs at the UKHC. The accessible population for this pilot project consisted of those RNs who were on orientation in CVICU at UKHC during the summer of 2022 and participated in the educational intervention as part of their orientation. Inclusion criteria for this study were: (a) RNs newly hired for a full-time position in CVICU at UKHC during the summer of 2022 and (b) completed at least one part of

the educational intervention. The exclusion criteria were (a) RNs who completed their orientation prior to the summer of 2022, (b) RNs who did not participate in the educational intervention, (c) RNs who were hired for part-time positions, (d) travel RNs, (e) non-RNs. A convenience sample of orientees who volunteered to complete pre- and post-intervention surveys was included in this study.

Procedure

IRB Approval

Prior to this study, the basic framework for this project and the project goals were presented to the NRC at the UKHC during the August 10th, 2022 meeting and received approval of the Council (appendix 1). A letter of support from the tele-ICU Program Coordinator at UKHC was obtained to demonstrate organizational support for this study. In September of 2022, the detailed project proposal, including description of the intervention, data collection methods, and privacy protection and data security measures, was submitted to the UK Medical IRB. The approval form the UK Medical IRB was received on September 19th, 2022 (appendix 2).

Description of Evidence-Based Intervention

The review of literature related to telehealth education suggested that multimodal approaches to nursing education in this area provide greater benefits than any one method alone (Gartz & O'Rourke, 2020; Rutledge et al., 2017). Guided by this finding, two educational methods were selected for this project from the multimodal framework for telehealth education proposed by Rutledge et al. (2017): didactics and clinical experience. This led to the development of a two-part educational intervention about tele-ICU.

The first part of the educational intervention consisted of a one-hour PowerPoint-based lecture about tele-ICU. This lecture provided a brief overview of what tele-ICU is, how it

operates, and what services and support are available to the bedside RNs through the tele-ICU. The lecture was based on the previously suggested telehealth curriculum, included information that addressed bedside RNs' concerns about tele-ICU identified in the literature, and incorporated input from eRNs currently employed at UKHC (Gibson et al., 2021; Li & Cotton, 2019).

The second part of the educational intervention consisted of a four-hour small group tele-ICU shadowing experience that was scheduled one to five days after the first part. During that time, bedside nurses were invited to the tele-ICU office and provided with an opportunity to observe tele-ICU workflow and participate in the tele-ICU tasks. This included patient monitoring, interactions with specialized tele-ICU software, communication with tele-ICU clinicians and bedside teams, and other activities depending on tele-ICU staffing availability and needs during the shadowing window. The participating nurses were also encouraged to ask questions about tele-ICU and discuss any concerns they had with the eRNs.

Measures and Instruments

The following demographic information was obtained through the pre-intervention survey: gender, age, highest nursing education level, total years of nursing experience, and prior tele-ICU experience of the participants. The level of nursing knowledge was assessed by a questionnaire consisting of three multiple choice questions and two select all that apply questions (appendix 3). These questions addressed the content presented in the one-hour lecture. Nursing attitudes were assessed utilizing a 10-item survey adapted from an instrument developed by Mullen-Fortino et al. (2012). This survey consisted of eight positive and two negative statements about tele-ICU (appendix 4). The positive statements were scored on a Likert scale from 1 to 5 with higher scores demonstrating greater agreement, and the negative statements were scored on

a Likert scale from 5 to 1 with higher scores demonstrating greater disagreement. In both cases, the higher score represented a more favorable attitude towards tele-ICU. The same knowledge and attitudes instruments were utilized in pre- and post-survey for both parts of the educational intervention. In addition, the post-survey for the second part of the educational intervention included a five-item questionnaire about perceived benefits of the shadowing experience (appendix 5). Each item of this section was also scored on a Likert scale from 1 to 5 with higher scores demonstrating greater agreement. Finally, monthly numbers of eLerts initiated by RNs in CVICU in the months of interest were obtained from Philips.

Data Collection

The study utilized a one group pretest-posttest design. Before the first part of the educational intervention, all potential participants received a paper packet containing a cover letter, demographics questionnaire, and pre- and post-intervention surveys assessing nursing knowledge and attitudes about tele-ICU. Volunteers were asked to anonymously fill out the demographics section and the pre-intervention survey before the lecture. Immediately after the lecture, participants were asked to respond to the post-survey questions. A packet containing two sets of the same knowledge and attitude instruments was provided to the potential participants before the second part of the educational intervention. In addition, the packet contained a survey evaluating the shadowing experience. Volunteers were asked to fill out the part of the packet labeled “pre-survey” before the shadowing and the part labeled “post-survey” after the shadowing. All packets were collected into a manila envelope at the end of each part of the educational intervention. In addition, institutional data about the number of eLerts from CVICU was obtained by the tele-ICU manager from Philips.

Data Analysis

The missing data was handled by pairwise deletion. All statistical analyses were completed utilizing IBM SPSS software. Categorical data were analyzed using frequency distribution. The paired sample t-test was used to calculate statistical significance of the differences between pre- and post-tests for each part of the educational intervention. Independent sample t-test was used to analyze the change in knowledge and attitude scores in the time between the lecture and the shadowing experience. A difference was considered statistically significant for $p<0.05$. In addition, the median number of eLerts in the three months after the intervention was compared to the median number of eLerts in the same three months of the previous year.

Results

Demographics

Twenty-three CVICU orientees participated in the educational intervention, and 100% of the participants completed pre- and post-intervention surveys. Of these participants, the majority were female (65.2%), and 95.7% were between 20 and 30 years of age. All participants had either associate (34.8%) or bachelor's (65.2%) degree in nursing, and most had less than one year of nursing experience (95.7%). Only two RNs (8.7%) had previously worked in a setting where tele-ICU services were available. All details of the participants' demographics are presented in table 2.

Findings

The effects of the first part of the educational intervention are summarized in table 3. The lecture resulted in a statistically significant ($p<0.001$) improvement in both knowledge about tele-ICU (from 57.4% [SD 25.1] to 85.2% [SD 19.3]) and attitude toward tele-ICU (from 3.7

[SD 0.6] to 4.4 [SD 0.4]) scores. In the period between the lecture and the shadowing experience, there were no statistically significant changes in the knowledge and attitude scores (table 4). The second part of the educational intervention did not influence the knowledge scores (table 5) but resulted in an additional statistically significant increase in the attitude score (from 4.2 [SD 0.4] to 4.5 [SD 0.4], $p<0.001$).

The analysis of each item in the knowledge questionnaire (appendix 3) supported the need to address significant knowledge deficiencies among nursing staff and highlighted specific areas of concern (figure 1). Question 2 of the knowledge survey, asking for the best way to contact tele-ICU, was the only one that was answered correctly by a significant number of participants (95.7%) before the education intervention. The baseline knowledge in other areas was poor, with just over 60% of participants correctly answering questions related to the services available to bedside RNs through tele-ICU (questions 1 and 5). Of particular concern was the lack of understanding of tele-ICU operations, with only 43.5% of participants correctly answering question 3 and 21.7% of participants correctly answering question 4. The lecture resulted in improved knowledge in all areas, with the percentage of participants who answer correctly increasing to 70% to 100% depending on the question.

Participants' feedback about the shadowing experience was excellent with 78.3% of RNs giving it an average rating of 5 on a 5-item 5-point Likert scale survey (mean 4.8 [SD 0.3]). The median number of eLerts in the three months after the intervention was 74, a small increase from 72 in the same three months of the previous year.

Discussion

The existing literature describes a lack of standards for tele-ICU and telehealth education in both academic and clinical settings supporting the need for more research in this area (Burt &

Kilroy, 2021; Chike-Harris, Durham, et al., 2020; Gibson et al., 2021; Rutledge et al., 2017). According to Rutledge, et al. (2017), the most comprehensive approach to telehealth education incorporates methods from four categories: didactics, simulations, projects, and clinical experience, but interplay between these components and their relative value have not been established (Burt & Kilroy, 2021). Nevertheless, a multimodal approach to telehealth education appears to be superior to any one method alone (Gartz & O'Rourke, 2020; Rutledge et al., 2017). Implementing an intervention utilizing all four educational methods was not feasible within the scope of this project. As a result, only two educational methods were selected for the multimodal educational intervention: didactics and clinical experience.

The didactic portion of this project consisted of a one-hour lecture and resulted in a significant increase in nursing knowledge about tele-ICU. In our institution, the pre-lecture survey demonstrated poor baseline knowledge of tele-ICU resources available for bedside RNs and extreme lack of understanding of tele-ICU operations. The lecture was successful in correcting the knowledge deficiency in all areas, and the shadowing experience did not provide additional benefit. This result supports and complements previous findings, reinforcing the idea that didactic methods are a valuable and inexpensive tool when knowledge transfer is one of the desired outcomes (Gartz & O'Rourke, 2020; List et al., 2019; Rutledge et al., 2017).

Beyond the knowledge acquisition, the didactic methods receive mixed reviews from previous researchers. Rutledge, et al. (2017) state that didactic teaching "does not address skill development and comfort with the technology" (p. 405). At the same time, others suggest that didactic methods can increase scores in confidence and attitude (Gartz & O'Rourke, 2020). This study supports the latter opinion with the significant improvement in attitude scores post-lecture. However, the second part of the education intervention, the clinical shadowing, was associated

with an additional significant increase in attitude scores. This result is congruent with previous findings that experiential learning is helpful in overcoming resistance to telehealth technologies and multimodal education provides the most benefits (Burt & Kilroy, 2021; Gartz & O'Rourke, 2020; Rutledge et al., 2017; Sapci & Sapci, 2018).

In addition to knowledge level and attitude toward tele-ICU, this study assessed participants' perception of the benefits of the shadowing experience. The participants had an overwhelmingly positive view of this part of the educational intervention, rating it as highly beneficial for their understanding of, comfort with, and acceptance of tele-ICU. This correlates with previous studies, all of which reported positive evaluation of the educational experience by the learners (Burt & Kilroy, 2021; Chike-Harris, Durham, et al., 2020; Douglas et al., 2018; Edirippulige & Armfield, 2017; Gartz & O'Rourke, 2020; Knight & Prettyman, 2020; LaManna et al., 2021; Lister et al., 2018; Merritt et al., 2018; Richard et al., 2016; Rutledge et al., 2014; Smith et al., 2018; Villegas et al., 2021).

In all reviewed studies, the outcome described as telehealth-related skills was measured by participants' subjective self-evaluation (Arends et al., 2021; Burt & Kilroy, 2021; Chike-Harris, Durham, et al., 2020; Edirippulige & Armfield, 2017; Gartz & O'Rourke, 2020; Gibson et al., 2020; Knight & Prettyman, 2020; Lister et al., 2018; Merritt et al., 2018; Rutledge et al., 2017; Sapci & Sapci, 2018). This study defined tele-ICU skills as a level of tele-ICU utilization as demonstrated by a monthly number of eLerts, which constitutes an objective and easily obtainable measure. However, the small post-intervention increase in the number of eLerts was not significant. This might be related to the design of this study, which was not able to control for the numerous other previously described factors affecting tele-ICU utilization, including bedside staffing levels, patient acuity, and familiarity of the bedside staff with tele-ICU providers

(Kahn et al., 2019; Moeckli et al., 2013; O'Shea et al., 2022). In addition, the small effect of the educational intervention on the tele-ICU utilization level might be related to the fact that study participants represented only a small fraction (less than 15%) of the total CVICU staff. A larger study with an ability to control for confounding factors might shed more light on the question of whether nursing education about tele-ICU translates into increase in tele-ICU utilization.

Implications for Practice and Research

Improvement in patient outcomes correlates with the degree of tele-ICU integration into the patient care process (Becker et al., 2019; O'Shea et al., 2022). However, full participation of the tele-ICU team in patient care is impossible when the bedside staff lack knowledge of what tele-ICU can contribute and experiences mistrust and discomfort with tele-ICU presence (Becker et al., 2019; Hoonakker & Carayon, 2018; Kahn et al., 2019; Li & Cotton, 2019). This study uncovered significant gaps in nursing knowledge about tele-ICU and supports previously stated need for healthcare organizations to develop consistent tele-ICU orientation processes and continuing tele-ICU education opportunities for the bedside staff (Gibson et al., 2021).

At this time, there is paucity of literature and no consensus in the approach to telehealth education, and literature related to tele-ICU is especially limited (Gartz & O'Rourke, 2020; LaManna et al., 2021; Rutledge et al., 2017). While this study demonstrated the effectiveness of a multimodal educational program in improving tele-ICU knowledge and attitudes among bedside nurses, it is not completely clear what the relative values of different educational methods are. Further studies are needed to identify most effective educational modalities and clarify the relationship between different approaches to tele-ICU education in a clinical setting in order to create guidelines for effective and efficient tele-ICU curriculum for bedside RNs. In addition, it has not been established how nursing education translates into tele-ICU

utilization level. Future research should focus on developing standardized tele-ICU utilization measures and studying how different educational approaches affect them. A study that includes a larger sample and is designed to control for factors that can confound tele-ICU utilization measures, such as bedside staffing, patient acuity, and familiarity of bedside staff with tele-ICU providers, has a potential to shed light on the connection between nursing education and the level of tele-ICU utilization.

Limitations

This study has several limitations that prohibit generalization of the study results. The main limitation is a very small sample size. Also, the sample was relatively homogenous, including mostly young, inexperienced RNs. Older nurses or nurses with more clinical experience might benefit more from a different educational approach. Additionally, shadowing in a tele-ICU office might not be feasible for organizations where tele-ICU is not in close proximity to the hospital. Also, while the evaluation tools were created based on literature and in consultation with internal experts, the validity of these tools have not been rigorously verified. Finally, the study design did not allow controlling for factors confounding tele-ICU utilization measures.

Conclusion

The purpose of this study was to develop and implement a multimodal educational intervention with the aim of increasing tele-ICU related knowledge, attitudes towards tele-ICU, and tele-ICU utilization by the bedside nurses. While this project succeeded in reaching the first two objectives, improving tele-ICU knowledge and attitude towards tele-ICU, the effects of this educational intervention on tele-ICU utilization remained unclear. This pilot program supports the effectiveness of a formal tele-ICU education in alleviating such barriers to tele-ICU

integration as inadequate knowledge and negative perception of tele-ICU. At the same time, this project highlights the need for more inquiry into what the best approaches to nursing education related to tele-ICU are. In addition, the study findings underscore the importance of future investigations that employ objective tele-ICU skill evaluation measures and assess translation of knowledge and skills into tele-ICU utilization.

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Table 1. Summary of the evidence

Author (s) (Date)	Design/ Method	Sample/ Setting	Major Variables and Their Definitions	Measurement of Major Variables	Data Analysis	Findings	Level of Evidence	Quality of Evidence; Critical Worth to Practice
Ali et al. (2015)	Cross-sectional descriptive survey	**Sample:** Schools of nursing (N=43) **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation **DV:** N/A	N/A	N/A	N/A	VI	**Limitations:** - low response rate - educational outcomes not measured **Implications:** - inadequate integration of telehealth in nursing school curricula - barriers described
Arends et al. (2021)	One cohort pre-/post-test	**Sample:** NP students (N=171) **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation, 3) project **DV:** educational outcomes: - knowledge; - skills	**DV:** 22-item competencies survey, each item rated on Likert scale from 1 (very unprepared) to 4 (very prepared)	Wilcoxon-matched pairs signed rank test	**DV:** significant increase in each item score (p=0.000)	IV	**Limitations:** - previous exposure to telehealth not assessed - subjective measures of outcomes **Implications:** - need for development of telehealth competency standards - telehealth education can be incorporated into NP curriculum
Burt & Kilroy (2021)	Descriptive study with post-intervention survey	**Sample:** NP students (N=6) **Setting:** Academic	**IV:** educational methods: 1) didactic modules – self-directed learning, 2) 3 SP simulations, 3) 8-hr clinical experience **DV1:** satisfaction with learning experience **DV2:** self-confidence	**DV1:** Satisfaction with Current Learning: 5-point Likert Scale **DV2:** Self-confidence in Learning: 5-point Likert Scale	Mean (SD)	**DV1:** mean 4.7 (SD 0.41) = learners satisfied with experience **DV2:** mean 4.42 (SD 0.40) = learners expressed high level of confidence in knowledge and skills gained	VI	**Limitations:** - small, convenience sample - outcomes measures descriptive, self-reported student perceptions **Implications:** - support for multimodal approach to teaching telemedicine competencies

Chike-Harris, Durham, et al. (2021)	Literature review	**Sample:** NP students; RN students; medical students; other healthcare professionals **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation, 3) projects, 4) clinical experiences **DV:** educational outcomes: - acceptance of technology; - knowledge; - skills; - satisfaction with the program	Specifics of educational programs and outcome measurements varied	N/A	- various programs have been created - all programs reported improvement of outcomes	V	**Limitations:** - measurement of outcomes not well defined - in some studies outcomes are not reported **Implications:** - low quality of existing evidence - more research with formal protocols and outcome definitions/ measurements is needed
Chike-Harris, Harmon, & van Ravenstein (2020)	One cohort pre-/post-test	**Sample:** NP students (N=27) **Setting:** Academic	**IV:** one-day immersion: 1) didactic, 2) simulation **DV:** knowledge	**DV:** 15-item test	average score	**DV:** increase from 59% to 64%	IV	**Limitations:** - small, convenience sample - no statistical significance described **Implications:** - programs need to create and implement telehealth curriculum
Douglas et al. (2018)	Feasibility study with two groups and pre-/post-test	**Sample:** Pilot cohort (N=11): RNs, RN students, other; Clinical cohort (N=5): ICU RNs **Setting:** Clinical (ICU, tele-ICU)	**IV:** educational methods: 20-min didactic + simulation with a healthy volunteer vs 60-min didactic + clinical ICU experience **DV1:** comfort with technology level **DV2:** perception of training experience	**DV1:** 5-point Likert Scale **DV2:** 5-point Likert scale	t-test; Fisher's exact test	**DV1:** ↑ post-training in both groups **DV2:** positive in both groups --- No statistically significant difference between groups	III	**Limitations:** - small, convenience sample - pre-existing positive relationship between bedside RNs and tele-ICU physician - study limited to a very specific clinical skill - long-term knowledge retention not tested **Implications:** - minimal training has a potential to improve comfort with tele-ICU-related skills

Edirippulige & Armfield (2017)	Literature review	**Sample:** healthcare students **Setting:** Academic, Clinical	**IV:** educational methods: 1) didactic, 2) simulation 3) clinical experiences **DV:** educational outcomes: - knowledge, - skills, - satisfaction with learning experience	Specifics of educational programs and outcome measurements varied	N/A	- all studies described positive outcomes	V	**Limitations:** - measurement of outcomes not well defined - included articles have small sample size **Implications:** - current evidence has multiple limitations - more research is needed to evaluate and compare educational methods - existing evidence supports multimodal approach to telehealth education
Erickson et al. (2015)	Descriptive study	**Sample:** NP students **Setting:** Academic	**IV:** educational methods: 1 hr didactic + 4 hr clinical **DV:** knowledge	Not defined	N/A	- increase in knowledge	VI	**Limitations:** - measurement of outcomes not defined **Implications:** - telehealth curriculum can be integrated into NP education
Fronczek et al. (2017)	Description of an educational program	**Sample:** RN and NP students **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation **DV:** N/A	N/A	N/A	N/A	VII	**Limitations:** - outcomes not measured **Implications:** - telehealth education can be integrated into nursing curriculum with different aspects integrated into different courses
Gartz & O'Rourke (2020)	Literature review	**Sample:** NP students **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation, 3) projects, 4) clinical experiences **DV:** educational outcomes: - knowledge,	Specifics of educational programs and outcome measurements varied	N/A	- didactic education improved knowledge and confidence; - didactic education and simulation increased competence, knowledge, and comfort level - clinical experience and projects are	V	**Limitations:** - measurement of outcomes not well defined - included articles have small sample size **Implications:** - current evidence has multiple limitations - more research is needed to evaluate and compare educational methods

			- comfort with the technology, - skills			used in combination with other methods and improve outcomes		- existing evidence supports multimodal approach to telehealth education
Gibson et al. (2021)	Description of an educational program	**Sample:** RN students **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation **DV:** N/A	N/A	N/A	N/A	VII	**Limitations:** - outcomes not measured **Implications:** - telehealth is not required in nursing education - health care organizations should create a formal telehealth orientation program and/or require telehealth continuing education
Gibson et al. (2020)	Descriptive study with post-intervention evaluation	**Sample:** NP students (N=22) **Setting:** Academic	**IV:** educational method: clinical experience **DV:** educational outcomes: - knowledge, - skills	**DV:** 8-item outcome evaluation tool ("not met", "met", "not observed")	n (%)	**DV:** 100% of students met 6of 8 criteria	VI	**Limitations:** - small, convenience sample - post-intervention evaluation only - previous exposure to telehealth not evaluated **Implication:** - clinical experience allows students to demonstrate competency
Gustin et al. (2020)	One cohort pre-/post-test	**Sample:** students of multiple health care professions (N=103) **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation (SP), 3) projects **DV:** knowledge	**DV:** 11-question survey with 5-point Likert scale	Wilcoxon-signed rank test	**DV:** significant increase in knowledge ($p<0.005$)	IV	**Limitations:** - convenience sample - subjective evaluation **Implication:** - telehealth education should be included in education of all healthcare providers
Knight & Prettyman (2020)	Descriptive study with post-intervention evaluation	**Sample:** RN students (N=10), NP students (N=19) **Setting:** Academic	**IV:** simulation **DV1:** attitude **DV2:** skills **DV3:** quality of training experience	**DV1:** Technology Acceptance Model-based survey with 5-point Likert scale	**DV1:** % of students scoring 4 or 5	**DV1:** 75% to 100% for different questions **DV2:** all students rated proficient **DV3:** 4 themes emerged	VI	**Limitations:** - small, convenience sample - post-intervention evaluation only - previous exposure to telehealth not evaluated

				DV2: skills checklist completed by faculty **DV3:** open-ended response				- skill measurement not quantifiable **Implications:** - simulation increases knowledge and provides opportunity to demonstrate skills
LaManna et al. (2021)	Descriptive study with post-intervention survey	**Sample:** NP students (N=33) **Setting:** Academic	**IV:** educational methods: 1) didactic: online learning module, 2) simulation: a telehealth visit with an acutely ill SP **DV1:** effectiveness of the learning experience **DV2:** realism of the learning activity **DV3:** usability of telehealth technology	**DV1:** Simulation Effectiveness Tool-Modified (SET-M): 3-poin Likert scale **DV2:** Evaluation of Simulation - Graduate Program tool: 5-poin Likert scale **DV3:** System Usability Scale (SUS): 5-poin Likert scale; scores converted to a standard score of 100	Mean (SD)	**DV1:** mean score range: 2.37-3.0 **DV2:** mean score range: 4.30-4.79 **DV3:** mean converted score: 77.66 (SD 10.10)	VI	**Limitations:** - small, convenience sample - post-intervention evaluation only - no knowledge/ skills assessment **Implications:** - students found experience beneficial and technology useful - more research is needed to develop evidence-based teaching and evaluation strategies
List et al. (2019)	One cohort pre-/post-test	**Sample:** NP students (N=22) **Setting:** Academic	**IV:** didactic (lecture) **DV:** knowledge	**DV:** 4-question survey with 4-point Likert scale	Mean (SD)	**DV:** mean score increased for all items of the survey (p=0.000)	IV	**Limitations:** - small, convenience sample - subjective knowledge assessment instrument **Implications:** - lecture increased subjective perception of knowledge
Lister et al. (2018)	One cohort pre-/post-test	**Sample:** RN students (N=73) **Setting:** Academic	**IV:** simulation (SP) **DV1:** skill **DV2:** attitude **DV3:** quality of training experience	**DV1 & DV2:** 5-point Likert scale **DV3:** Simulation Design Scale	Mean (SD)	**DV1 & DV2:** mean score increased for all items of the survey (p<0.02) **DV3:** positive response to all items	IV	**Limitations:** - small, convenience sample - subjective skill self-assessment instrument **Implications:**

				and Self-Confidence in Learning Scale (5-point Likert) – post-intervention only				- simulation is a valuable method in teaching about telehealth
Mennenga et al. (2016)	One cohort pre-/post-test	**Sample:** NP students (N=48) and faculty (N=7) **Setting:** Academic	**IV:** simulation **DV:** knowledge	**DV:** 21-iten survey with 5-point Likert scale	t-test	**DV:** significant increase ($p<0.02$)	IV	**Limitations:** - small, convenience sample - subjective knowledge self-assessment instrument **Implications:** - simulation is a valuable method in teaching about telehealth
Merritt et al. (2018)	Descriptive study with post-intervention survey	**Sample:** NP students (N=26) **Setting:** Academic	**IV:** simulation **DV1:** knowledge **DV2:** skill **DV3:** quality of training experience	All outcomes measured be a survey scored on a 5-point Likert scale	Mean (SD), %	High scores for all items of the survey	VI	**Limitations:** - small, convenience sample - subjective knowledge & skill self-assessment instrument - post-intervention evaluation only **Implications:** - simulation is a valuable method in teaching about telehealth
Richard et al. (2016)	Non-randomized multigroup study with pre-/post-test	**Sample:** physicians (N=73), RNs (N=139), auxiliary RNs (N=9), radiology technicians (N=4) **Setting:** Clinical (hub-and-spokes telestroke system)	**IV:** simulation **DV1:** knowledge **DV2:** quality of training experience	**DV1:** 10 multiple choice questions + 4 short-answer questions **DV2:** scale 0 to 5 (higher score = better)	Wilcoxon signed-rank test, Mann-Whitney U test	**DV1:** knowledge increased in all subgroups as evidenced by the following increase in median test score ($p<0.001$): - physicians: 67% to 88% - RNs: 54% to 80% - auxiliary RN/ radiology technicians: 51% to 78%	III	**Limitations:** - no skill or patient outcome assessment - long-term knowledge retention not tested **Implications:** - simulation increases knowledge - studies assessing skills / patient outcomes are needed

						DV2: 95% of participants - score of 5		
Rutledge et al. (2014)	Descriptive study with post-intervention survey	**Sample:** NP students (N=60) **Setting:** Academic	**IV:** educational methods: 1) simulation (SP), 2) project, 3) clinical experiences **DV:** educational outcomes: - attitude, - value of the educational experience	**DV:** survey with 5-poit Likert scale and open responses	Mean	- report of perceived improvement in attitude towards telehealth - positive perception of the program	VI	**Limitations:** - convenience sample - post-intervention evaluation only **Implications:** - comprehensive program resulted in increased appreciation of telehealth
Rutledge et al. (2017)	Literature review	**Sample:** NP students **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation, 3) projects, 4) clinical experiences **DV:** educational outcomes: - knowledge, - comfort with the technology, - skills	Specifics of educational programs and outcome measurements varied	N/A	- didactic education improves knowledge; - experiential activities help overcome resistance to using telehealth; - multimodal education results in greater benefits	V	**Limitations:** - measurement of outcomes not well defined **Implications:** - found paucity of literature - need for more research to develop competencies/ curriculum - existing evidence supports multimodal approach to telehealth education
Sapci & Sapci (2019)	One cohort pre-/post-test	**Sample:** RN students (N=206) **Setting:** Academic	**IV:** educational methods: 3-hr course: didactic + 2 laboratory exercises **DV:** educational outcomes: - knowledge, - attitudes, - skills	**DV:** 5 item survey: 5-poin Likert scale	Mann Whitney U-test; Wilcoxon signed rank test	- statistically significant increase in confidence in knowledge and skills - statistically significant increase in positive view of technology	IV	**Limitations:** - study limited to undergraduate students - study limited to very specific technical skills **Implications:** - skill training is associated with confidence and adoption of technology - more research is needed to establish best practice in telehealth education

Smith et al. (2018)	Descriptive study with post-intervention survey	**Sample:** NP students **Setting:** Academic	**IV:** educational methods: 1) didactic, 2) simulation (SP) **DV:** educational outcomes: - attitude, - value of the educational experience	**DV:** faculty-guided debriefing	N/A	- summary of the debriefings included perceived usefulness of telehealth and the need for NPs to be knowledgeable about it - positive feedback about the simulation	VI	**Limitations:** - convenience sample - post-intervention evaluation only - no objective outcome measures **Implications:** - telehealth education should be implemented early in the NP curriculum
Villegas et al. (2021)	Cross-sectional descriptive study with post-intervention survey	**Sample:** RN students (N=205) **Setting:** Academic	**IV:** simulation (SP **DV1:** telehealth knowledge prior to simulation **DV2:** usefulness of telehealth in practice **DV3:** benefits of telehealth **DV4:** value of the educational experience	**DV1:** "high", "some", "none" **DV2:** "yes", "no" **DV3:** open response, categorized by researchers **DV4:** Helpful? "yes", "no"	frequency n (%)	**DV1:** n = 139 (67.5%) reported not knowing about telehealth before the simulation **DV2:** n = 195 (94.7%) could use telehealth in practice **DV3:** - overcoming the constraint of distance: n=77 (38.5%) - helping those without access to healthcare: n=60 (30%) **DV4:** n=199 (96.6%) found simulation helpful	VI	**Limitations:** - post-intervention evaluation only - no knowledge/ skills assessment **Implications:** - students found technology useful - telehealth simulations can be incorporated in various fields of nursing education

DV = dependent variable; hr = hour; ICU = intensive care unit; IV = independent variable; min = minutes; N/A = not applicable; NP = Nurse Practitioner; RN = registered nurse; SD = standard deviation; SP = standardized patient

Table 2. Demographic characteristics of the participants (N=23)

	n (%)
Gender	
Male	8 (34.8%)
Female	15 (65.2%)
Age	
20-30	22 (95.7%)
Over 40	1 (4.3%)
Nursing education level	
Associate degree	8 (34.8%)
Bachelor's degree	15 (65.2%)
Years of nursing experience	
0-1	22 (95.7%)
1-3	1 (4.3%)
Previous experience of working where tele-ICU is available	
Yes	2 (8.7%)
No	21 (91.3%)

Table 3. Pre- and post-lecture knowledge and attitude scores

	Pre-intervention *Mean* (SD)	Post-intervention *Mean* (SD)	*p*
Knowledge (potential range 0-100%)	57.4 (25.1)	85.2 (19.3)	<0.001
Attitude (potential range 1-5)	3.7 (0.6)	4.4 (0.4)	<0.001

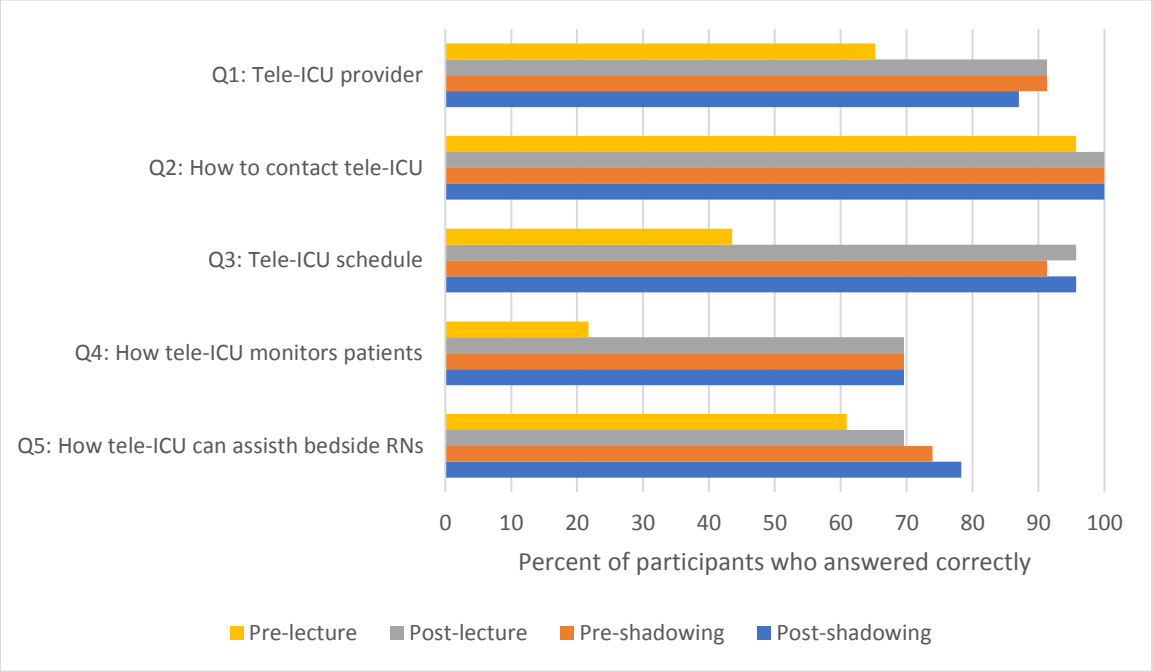
Table 4. Post-lecture and pre-shadowing knowledge and attitude scores

	Post-lecture *Mean* (SD)	Pre-shadowing *Mean* (SD)	*p*
Knowledge (potential range 0-100%)	85.2 (19.3)	85.2 (20.2)	1.0
Attitude (potential range 1-5)	4.4 (0.4)	4.2 (0.4)	0.27

Table 5. Pre- and post-shadowing knowledge and attitude scores

	Pre-intervention *Mean* (SD)	Post-intervention *Mean* (SD)	*p*
Knowledge (potential range 0-100%)	85.2 (20.2)	86.1 (18.5)	0.71
Attitude (potential range 1-5)	4.2 (0.4)	4.5 (0.4)	<0.001

Figure 1. Changes in nursing knowledge by question



Appendix 1. Nursing Research Council Approval

UKHealthCare

August 10, 2022

Dear Olga Vulakh,

Your proposal entitled, "*Effectiveness of a Multimodal Educational Program in Increasing Understanding and Utilization of Tele-ICU Resources by Critical Care Nurses: A Pilot Study*" was reviewed during our August 10th meeting of the Nursing Research Council at the University of Kentucky Medical Center, and we are happy to report that your proposal has been approved. If you have not yet obtained approval for your research through the University of Kentucky Institutional Review Board (IRB), you must complete this process as well.

The Nursing Research Council reviews all proposals to conduct scientific inquiry that involve UK nursing staff in an effort to assess for a number of indicators: to determine the feasibility of conducting the proposed research, to establish the level of support from nursing management or administration to conduct the research, to determine the applicability to nursing, to facilitate IRB review ensuring proper protections are present, and to assess the completeness of the proposal. If your proposal is amended in any way such that the methods or procedures are modified significantly, your proposal must be re-submitted for review by this Council. ***You are required to provide your IRB approval date, study status and completion date to this council for compliance with Magnet verification requirements.***

Please contact me if you need further assistance, have questions, or wish to discuss anything.

Sincerely,

Jonathan High, BSN, RN, CCRN, RN-BC
Chair, Nursing Research Council

Madison Matlock, BSN, RN
Co-Chair Nursing Research Council

Caroline Browning, MSN, RN
Co-Chair Nursing Research Council

Office of the Executive Vice President for Health Affairs

University of Kentucky • 317 Wethington Building • 900 South Limestone • Lexington, Kentucky 40536-0200
Phone: (859) 323-5126 • Fax: (859) 323-1918 • www.ukhealthcare.uky.edu

Appendix 2. University of Kentucky Medical Institutional Review Board Approval

University of Kentucky | Office of Research Integrity
IRB, RDRC

XP Initial Review

Approval Ends:
9/18/2023

IRB Number:
79866

TO: Olga Vulakh, BSN
College of Nursing
PI phone #: 8593126946

PI email: olga.vulakh@uky.edu

FROM: Chairperson/Vice Chairperson
Medical Institutional Review Board (IRB)

SUBJECT: Approval of Protocol

DATE: 9/19/2022

On 9/19/2022, the Medical Institutional Review Board approved your protocol entitled:

Effectiveness of a Multimodal Educational Program in Increasing Understanding and Utilization of Tele-ICU Resources by Critical Care Nurses: A Pilot Study

Approval is effective from 9/19/2022 until 9/18/2023 and extends to any consent/assent form, cover letter, and/or phone script. If applicable, the IRB approved consent/assent document(s) to be used when enrolling subjects can be found on the approved application's landing page in E-IRB. [Note, subjects can only be enrolled using consent/assent forms which have a valid "IRB Approval" stamp unless special waiver has been obtained from the IRB.] Prior to the end of this period, you will be sent a Continuation Review (CR)/Annual Administrative Review (AAR) request which must be completed and submitted to the Office of Research Integrity so that the protocol can be reviewed and approved for the next period.

In implementing the research activities, you are responsible for complying with IRB decisions, conditions and requirements. The research procedures should be implemented as approved in the IRB protocol. It is the principal investigator's responsibility to ensure any changes planned for the research are submitted for review and approval by the IRB prior to implementation. Protocol changes made without prior IRB approval to eliminate apparent hazards to the subject(s) should be reported in writing immediately to the IRB. Furthermore, discontinuing a study or completion of a study is considered a change in the protocol's status and therefore the IRB should be promptly notified in writing.

For information describing investigator responsibilities after obtaining IRB approval, download and read the document "PI Guidance to Responsibilities, Qualifications, Records and Documentation of Human Subjects Research" available in the online Office of Research Integrity's IRB Survival Handbook. Additional information regarding IRB review, federal regulations, and institutional policies may be found through ORI's web site. If you have questions, need additional information, or would like a paper copy of the above mentioned document, contact the Office of Research Integrity at 859-257-9428.

see blue.
405 Kinkead Hall | Lexington, KY 40506-0057 | P: 859-257-9428 | F: 859-257-8995 | www.research.uky.edu/ori/
An Equal Opportunity University

Appendix 3. Nursing Knowledge Questionnaire

For questions 1 - 3 chose ONE best answer

1. The provider available at eICU is a(an)
   - o Advanced practice provider (NP or PA)
   - o Resident
   - o Fellow
   - o Attending

2. What is the best way to contact eRN during a patient emergency?
   - o Call the eICU office
   - o Press the eLert button
   - o Text via Secure Chat
   - o Call eRN's desk phone

3. eRN's shifts are
   - o 6a-6p/6p-6a
   - o 7a-7p/7p-7a
   - o 8a-8p/8p-8a

For questions 4 – 5 select ALL that applies

4. How do eRNs monitor patients?
   - □ Analyzing eCare Manager patient acuity trends
   - □ Monitoring telemetry in real time
   - □ Interpreting eCare Manager vital signs alerts
   - □ Watching all patients at all times through the camera

5. It's 13:00, and the team is about to intubate your patient. You had a very busy day and decided to ask eICU to help with documentation. What can eRN chart for you?
   - □ Time out for intubation
   - □ Vital signs during the procedure
   - □ Medications given for the intubation
   - □ 8 am patient assessment

Appendix 4. Nursing Attitude Instrument

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I know when to contact eICU					
I know how eICU can help me with my daily tasks					
I regularly incorporate interventions suggested by eICU staff into my patient's care					
I know how eICU can help me during patient decline/emergency					
Having eICU improves patient and family satisfaction					
Having eICU improves patient safety					
Having eICU decreases patient privacy					
The eICU cameras make me feel like I am being "spied upon" when working in my patient's room					
I feel more secure knowing the eICU is quickly available when I need help					
Overall, I am satisfied with the service that eICU provides					

Appendix 4. Nursing attitude instrument. Adapted from Mullen-Fortino et al. (2012).

Appendix 5. Evaluation of Shadowing Experience

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The shadowing improved my understanding of eRN's workflow					
The shadowing increased my knowledge of resources available through eICU					
The shadowing increased my comfort with eICU presence					
The shadowing was a valuable educational experience					
I will utilize eICU more frequently than I did before the shadowing					