Article

# Liberation from Ventilation: An Intervention Study in Public Adult Intensive Care Units in the Eastern Cape Province of South Africa

**Benedict Raphael Oamen**
https://orcid.org/0000-0002-7300-5545
Nelson Mandela University,
South Africa
benoamen@gmail.com

**Portia Jordan**
https://orcid.org/0000-0001-6457-2831
Stellenbosch University,
South Africa
pjordan@sun.ac.za

**Wilma ten Ham-Baloyi**
https://orcid.org/0000-0002-2253-6354
Nelson Mandela University,
South Africa
Wilma.tenHam-Baloyi@mandela.ac.za

**Emmanuel Zamokwakhe Hlungwane**
https://orcid.org/0000-0002-3875-5914
Nelson Mandela University,
South Africa
mcgear.vk@gmail.com

## Abstract

Implementing evidence-based guidelines is one way of addressing the knowledge gap of critical care nurses regarding the ventilator liberation of critically ill adult patients in South Africa. A quasi-experimental intervention study using a pre-test/post-test design to measure critical care nurses' knowledge on ventilator liberation of adult patients in intensive care units was conducted. The critical care nurses were purposively sampled into three groups and their knowledge was measured before an educational intervention, and three months after. Data was collected with pre/post-test questionnaires, n1=115 pre-test and n2=90 post-test, respectively. An educational intervention using a PowerPoint presentation, printed copies of the guidelines, posters as reminders, and informal monitoring visits (Intervention Group One) had an insignificant effect (p=0.371; Cohen's d <0.20) on the improvement of the respondents' knowledge score (62,93 versus 65,22). Handing out printed copies of guidelines alone (Intervention Group Two) had a small effect (p=0.033; Cohen's d=0.49 small) but did not improve respondents' knowledge score (60,34 versus 53,41). The absence of an educational intervention (Control Group) had an insignificant effect (p=0.884; Cohen's d <0.20) on the improvement of respondents'

UNISA university of south africa PRESS

Africa Journal of Nursing and Midwifery
https://upjournals.co.za/index.php/AJNM
Volume 23 | Number 1 | 2021 | #7887 | 18 pages

https://doi.org/10.25159/2520-5293/7887
ISSN 2520-5293 (Online)

knowledge score (59,60 versus 60,33). Across the three groups, intensive care unit experience had a moderate effect (p=0,018; Cohen's d=0.67 medium) on the way critical care nurses responded to the pre/post-test questionnaires. Respondents lacked knowledge of ventilator liberation practices in the study context, and this can be addressed using combined educational intervention methods. Sequel studies using different educational intervention methods are recommended that take into account the diversity within the study population.

**Keywords:** critical care nurses; intensive care unit; educational intervention; evidence-based guidelines; ventilator liberation

## Introduction

Regardless of the life-saving attributes of mechanical ventilation, the end-goal is to reduce artificial or assisted ventilation and liberate the mechanically ventilated patient (MVP) to enable a greater percentage of the patient's respiratory effort. Liberation is the removal of an artificial airway (endotracheal tube [ET] or tracheostomy tube [TT]) from an invasively MVP, after meeting the criteria for liberation readiness. Some authors define "ventilator liberation" as the termination of the weaning process and removal of an artificial airway when a patient is hemodynamically stable and can initiate an inspiratory effort (Esteban et al. 2008, 170; MacIntyre 2004, 830; Peñuelas, Thille, and Esteban 2015, 74). In contrast, weaning is switching to natural breathing by reducing ventilatory support or withdrawal of a life-support system (Hess 2002, 2154; Kollef et al. 1998, 52; Mancebo 1996, 1923). Weaning is a holistic process and not an outcome, which commences the moment a patient is bound to be intubated and is not the same as liberation. In other words, ventilator liberation is the termination of the weaning process (Conti et al. 2014, 1). The concept of ventilator liberation will, therefore, be used throughout this article.

Suboptimal knowledge of critical care nurses and other healthcare professionals concerning ventilator liberation of MVPs in the intensive care unit (ICU) necessitates protocolised steps to prevent heterogeneous practices (Blackwood et al. 2011, 1; Rose et al. 2014, e54). The majority of the patients admitted in ICUs are mostly mechanically ventilated (Aitken, Marshall, and Chaboyer 2015, 474; Jordan 2011, 45), and findings in South Africa have identified knowledge gaps regarding the evidence-based guidelines (EBGs) on weaning and ventilator liberation practices in ICUs (Demingo 2011, 98; Fischer 2014, 82). An international study reported that 0.4%–25% of patients in ICUs are reintubated following weaning and liberation failure (LF); thus, ventilator liberation is very significant because the percentage of patients in the ICU is higher than the percentage (0.1%–0.45%) of patients in the operating and recovery room (Cavallone and Vannucci 2013, 368; Epstein 2002, 535).

The American Thoracic Society (ATS) and American College of Chest Physicians (CHEST) collaborated to develop and publish six evidence-based clinical practice guidelines on ventilator liberation from mechanical ventilation in critically ill adults

(Fan et al. 2017, 441; Ouellette et al. 2017, 166). Only three recommendations were selected for this study based on the quality of the available evidence, and equilibrium of their benefits and harms as presented in the CHEST/ATS document.

The objective of critical care nurses is to function adequately as healthcare providers in the ICU, and this requires the implementation of EBGs that include scientifically underpinned recommendations for optimising patient care and safety. Early implementation of the EBGs on ventilator liberation in the ICU has shown exciting results and substantial benefits regarding early extubation, decrease in ICU-stay and subsequently reductions in healthcare costs (Ouellette et al. 2017, 179). Breaking the frequency of complications related to the increased duration of mechanical ventilation is crucial.

## Problem Statement

The prevalence of LF in ventilated adult patients in ICUs has caused negative health outcomes such as tracheomalacia, tracheostenosis, dysphagia, sore throat, hoarseness/stridor, choking sensation, ventilator-acquired pneumonia, loss of upper airway patency occurring from re-intubation, prolonged stay in the ICU and hospital, and increased hospital costs (Jordan 2011, 28; Pierce 2007, 73). However, at the time the study was conducted, there were no updated algorithms or protocols guiding critical care nurses on ventilator liberation practices in the public ICUs across the Eastern Cape Province. Critical care nurses working in these settings care for ventilated adult patients, but the question is how knowledgeable they are regarding ventilator liberation, considering their role as healthcare providers in the ICU.

## Objective of the Study

The objective of the study was therefore to investigate critical care nurses' knowledge of ventilator liberation of adult patients by developing and implementing an educational intervention based on three existing recommendations from the evidence-based guidelines on ventilator liberation, and to evaluate the effect of the intervention on their knowledge.

## Methods

### Study Design and Setting

Before commencing this research study, ethical clearance from the Faculty of Postgraduate Studies Committee (FPGSC) of Nelson Mandela University (reference number: H17-HEA-NUR-019), and the Eastern Cape Department of Health (reference number: EC_201712_017) was obtained. Permission was granted by the chief executive officers of the teaching/tertiary public hospitals where the study was conducted.

The study setting included five public hospitals, each with one open ICU, comprising a total of 56 beds, across the Eastern Cape Province of South Africa. The five public adult

ICUs included four general intensive care units and one cardiothoracic intensive care unit. Critically ill adult patients who need post-surgical and medical intensive care including patients with severe burn injuries requiring mechanical ventilation are admitted in the four general ICUs. Equally patients who are managed for post-cardiac surgeries are admitted in the cardiothoracic intensive care unit.

The authors employed a quantitative quasi-experimental intervention study using a pre-test/post-test design. A pre-test/post-test control group design was used as it provides evidence of cause and effect and clarifies inherent variations in intervention research using controls similar to the intervention group in terms of standards of practice (Grove, Gray, and Burns 2015, 230–31; Handley et al. 2018, 10). Employing this design allowed for comparisons between the three groups (the educational intervention in two intervention groups and no educational intervention in a control group) as well as to demonstrate a high level of internal validity. The study was divided into three phases. In Phase One, respondents completed the pre-test questionnaire; in Phase Two, the educational intervention was implemented, and in Phase Three, the respondents completed the post-test questionnaires.

## Population and Sampling

The total number of eligible respondents was 150 purposively selected critical care nurses who have cared for ventilated adult patients for at least three months in the ICUs of five hospitals in the Eastern Cape. Due to the limited population sample, randomisation was not possible and therefore purposive sampling was used to select the critical care nurses who have been working in the five public adult ICUs for at least three months to ensure that the study respondents were familiar with the technical terms used in the questionnaires and educational intervention. Critical care nurses were selected as in the context of the South African public ICUs they monitor and care for ventilated adult patients closely by the bedside, based on their knowledge from Critical Care Nursing training or acquired ICU experience. The successful implementation of the best available evidence in ventilator management thus required the study to target critical care nurses because of their understanding of the ICU setting and research topic (Balas et al. 2012, 3). The exclusion criteria encompassed the critical care nurses in the pilot study, paediatric/neonatal intensive care nurses or nurses working in those units, undergraduate nursing students, as well as enrolled and auxiliary nurses.

Considering the small accessible population, and the geographical location of the public hospitals, respondents were purposefully selected into three groups to prevent contamination of the educational intervention during the research and to permit flexibility of access into the research site. There were two intervention groups: Intervention Group One (IG1)—ICU1 and ICU2, Intervention Group 2 (IG2)—ICU3 and ICU4, and one control group (CG)—ICU5. The two intervention groups and the control group were further apart (see Figure 1).

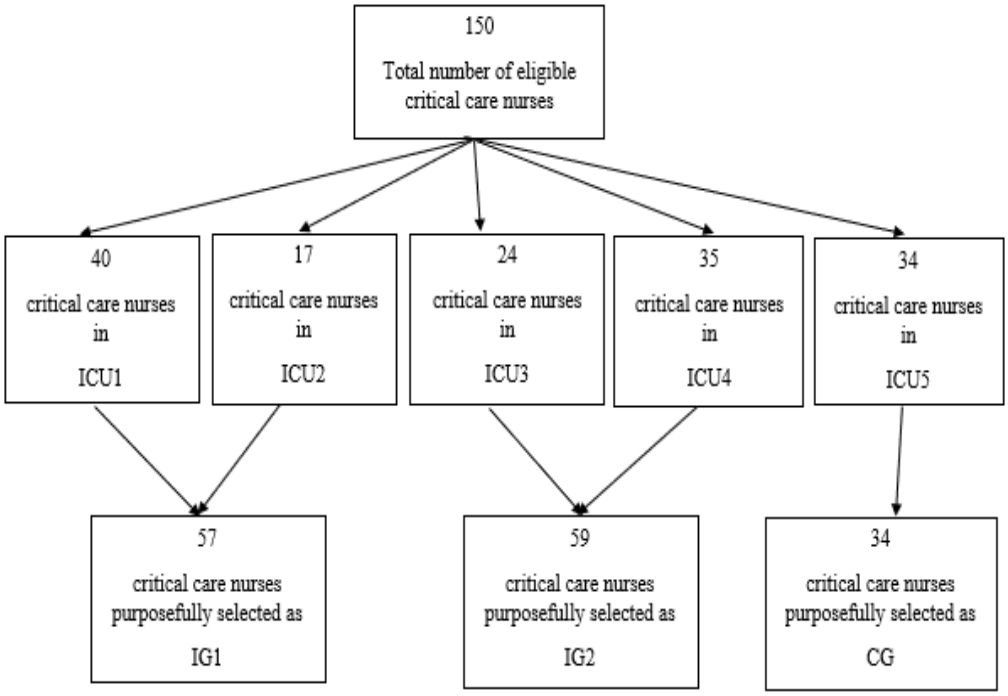


**Figure 1:** Sampling framework

## Data Collection Tool

The pre-and post-test questionnaires comprised closed-ended questions developed by the authors guided by a robust review of literature. The questionnaires both contained two sections. Section A (6 items) captured the demographic data (gender, the age of the critical care nurses, years of ICU experience, the position held in the ICU, additional qualifications in Critical Care Nursing, and if critical care nurses attend educational intervention programmes). Section B (21 items) captured knowledge related to the EBGs on ventilator liberation. The post-test questionnaires contained an additional Section C (6 items) that captured the effect of the educational intervention. Screener questions were used to filter out respondents who neither completed the pre-test questionnaire nor engaged in the educational intervention.

## Data Collection

Respondents in each ICU work in two shifts for every 12 hours a day and take turns to go on lunch hours or breaks. The first author distributed the questionnaires to both shifts in their first tea break in order to provide all eligible participants with the questionnaires at a similar time in their shift and to obtain a response rate as high as possible. The

estimated time within each shift for the completion of the questionnaires was 10–15 minutes.

The same pre-test questionnaires were administered across the three groups to measure their knowledge base between the months of June and July 2018 (Phase One). Likewise, the same post-test questionnaires were administered to measure the effectiveness of the educational intervention in IG1 and IG2, as well as in the CG to test for knowledge retention compared to the intervention groups (Phase Three). The administration of the post-test questionnaires was scheduled to begin three months after the educational intervention, between the months of September and October 2018. Some of the respondents who completed the pre-test questionnaire and educational intervention dropped out in the post-test, leading to sample attrition.

## The Educational Intervention (Phase Two)

An educational intervention was used as a tool for the implementation of EBGs to assist professional healthcare workers to adopt and integrate them into evidence-based practices (Jordan et al. 2017, 359). The educational intervention centred on selected (3) EBGs on ventilator liberation advocating inspiratory pressure augmentation (IPA) during an initial spontaneous breathing trial (SBT), protocols minimising sedation, and preventative non-invasive ventilation (NIV) (Ouellette et al. 2017, 166) complemented by specific contents from the ABCDEF Bundles developed by the Society of Critical Care Medicine (Morandi et al. 2017, e1114), which were relevant to the study. The three EBGs on ventilator liberation were selected for the educational intervention as they were deemed applicable and feasible in the context of a middle-income country such as South Africa. The educational intervention was critically reviewed by experts in the field of critical care sciences (see Reliability and Validity section for details), since such guidelines were not available in the ICUs selected for the study.

The educational intervention aimed at effective dissemination of information regardless of the ICU years of experience or knowledge differences of the critical care nurses and consisted of a 15-minute PowerPoint presentation (of which handouts were not shared due to copyright concerns) based on the content of the guidelines, printed copies of the guidelines, coloured printed posters that were attached to notice boards, corridors of the ICUs and strategic points in the ICUs as reminders, and informal monitoring visits where questions linked to the PowerPoint presentation, printed copies and posters were further discussed and clarified. IG1 received the full intervention; IG2 received only printed copies. ICUs in the same intervention group received the intervention immediately after they completed the pre-test questionnaire, during their first break. CG did not receive any intervention.

## Data Analyses

The data obtained was captured onto a Microsoft Excel spreadsheet before it was analysed. The data was analysed with the assistance of a senior statistician using

Statistica (version 13) data analysis software. Descriptive and inferential analyses were conducted. The chi-square was used to determine the relationship between the variables by signifying whether there was knowledge increase at the post-test level. Cramer's V was used to determine the strengths of association for significant chi-square results. The t-test was conducted to test the differences between the mean knowledge scores within each group. Cohen's d (the practical significance) provided a report of the effect size for significant t-test results. Analysis of variance (ANOVA) was used to determine the variation between each group in the pre- and post-test. Statistical significance was defined at $P \leq 0.05$.

## Validity and Reliability

The validity of the pre- and post-test questionnaires was ensured by review from the supervisors and the statistician whereafter the pre- and post-test questionnaires and the educational intervention were reviewed by seven experts in the field of critical care from both the private and public healthcare sectors, which comprised two intensivists, a clinical technologist-pulmonology technician, an anaesthetist, and three professional critical care nurses. One of the critical care nurses was an academic at one of the local universities with many years of ICU experience. A score sheet was adapted from the Appraisal of Guidelines for Research and Evaluation II (AGREE II) tool. The AGREE II tool is a generic instrument used to appraise the methodological rigour and transparency with which a guideline or tool is developed (Brouwers et al. 2010, E839). The four domains of the score sheet used were the feasibility, relevance, technicality and content significance of the pre/post-test questionnaires and educational intervention in the context of public ICUs in South Africa. Each expert was required to rate the technicality of the terminologies used in the educational intervention and questionnaires in terms of consistency and the sequence/flow of the questions in the questionnaires. The experts' reviews and comments were taken into consideration regarding the technicality of the language used in the questionnaires and the educational intervention.

A consensus was reached between the reviewers that the technicality of the terminologies was within the nursing domain and context of critical care sciences, within which the respondents were working. The domain score for the review was 62%; it was above the cut-off score of 50%. Suggestions from the expert reviewers were adopted to finalise the questionnaires and educational intervention before implementation.

A 13-respondent pilot study was conducted in a six-bedded ICU to test the suitability of the language and terminologies used in the pre- and post-test questionnaires and educational intervention. The findings of the pilot study were not included in the main study, although some of the comments recorded from the pilot study were used to refine the technical terms (i.e., provide alternative words) used in the questionnaire and it was considered to allocate five minutes extra for completion of the post-test questionnaire. The Cronbach's alpha coefficient for the factors for both pre-test and post-test regarding knowledge testing was 0.64, which was an acceptable score.

## Results

As shown in Figure 1, the total sample size of recruited respondents in the three groups was 150. A total of 150 pre- and post-test questionnaires were administered to the study sample. Of these, 35 (23%) were damaged or incomplete and could not be analysed, leaving a response rate of 115 (77%) for the pre-test questionnaire. Some of the respondents who completed the pre-test questionnaire and educational intervention did not participate in the post-test. In aggregate, 95 (63%) post-test questionnaires were given out, and of these 90 (60%) were returned viable, which was 78% of the number of respondents at the pre-test level. In total, there were 205 viable pre- and post-test questionnaires from the three groups captured into the Microsoft Excel spreadsheet.

## Respondents' Demographics

As shown in Table 1, the demographic data collected during the pre- and post-test showed that most respondents were females (89%); more than half (63%) were aged between 40–59 years, and 73% had five years' or more ICU experience; the highest proportion (63%) had an additional qualification in Critical Care Nursing, and the majority (86%) attended educational programmes aimed at continuous professional development. The majority of the respondents (83%) were critical care nurses working without additional function as a shift leader, unit manager or clinical facilitator. Inferential analysis of the demographic data across the three groups at the pre- and post-test level shows there were non-statistically significant ($p > 0.05$) findings.

**Table 1:** Demographics

| **Demographics** | **Pre/Post** | | | | | |
|---|---|---|---|---|---|---|
| | **Pre-test n1 (%)** | | **Post-test n2 (%)** | | **Total N (%)** | |
| **Gender** | **Pre n1** | | **Post n2** | | **Total** | |
| Female | 102 | 92**%** | 76 | 85**%** | 178 | 89**%** |
| Male | 9 | 8**%** | 13 | 15**%** | 22 | 11**%** |
| **Total** | 111 | 100**%** | 89 | 100**%** | 200 | 100**%** |
| $Chi^2$ (d.f. = 1, n = 200) = 2.13; p = .144 | | | | | | |

| **Age** | **Pre n1** | | **Post n2** | | **Total** | |
|---|---|---|---|---|---|---|
| Less than 20 years | 1 | 1% | 2 | 2% | 3 | 1% |
| 20–29 years | 14 | 12% | 11 | 12% | 25 | 12% |
| 30–39 years | 2 | 20% | 23 | 26% | 46 | 23% |
| 40–49 years | 25 | 22% | 28 | 31% | 53 | 26% |
| 50–59 years | 50 | 44% | 26 | 29% | 76 | 37% |
| **Total** | 113 | 100% | 90 | 100% | 203 | 100% |
| Chi² (d.f. = 4, n = 203) = 5.91; p = .206 | | | | | | |
| **ICU Experience** | **Pre n1** | | **Post n2** | | **Total** | |
| < 5 years | 30 | 27% | 25 | 28% | 55 | 27% |
| 5–9 years | 20 | 18% | 24 | 27% | 44 | 22% |
| 10–19 years | 29 | 26% | 17 | 19% | 46 | 23% |
| 20 years and more | 33 | 29% | 24 | 27% | 57 | 28% |
| **Total** | 112 | 100% | 90 | 100% | 202 | 100% |
| Chi² (d.f. = 3, n = 202) = 3.01; p = .390 | | | | | | |
| **Position** | **Pre n1** | | **Post n2** | | **Total** | |
| Professional nurse | 89 | 78% | 79 | 89% | 168 | 83% |
| Unit manager | 6 | 5% | 3 | 3% | 9 | 4% |
| Shift leader | 19 | 17% | 6 | 7% | 25 | 12% |
| Clinical facilitator/mentor | 0 | 0% | 1 | 1% | 1 | 0% |
| **Total** | 114 | 100% | 89 | 100% | 203 | 100% |
| Chi² (d.f. = 3, n = 203) = 6.37; p = .095 | | | | | | |
| **Additional ICU Qualification** | **Pre n1** | | **Post n2** | | **Total** | |
| Yes | 70 | 61% | 57 | 64% | 127 | 62% |
| No | 45 | 39% | 32 | 36% | 77 | 38% |
| **Total** | 115 | 100% | 89 | 100% | 204 | 100% |
| Chi² (d.f. = 1, n = 204) = 0.22; p = .643 | | | | | | |
| **Attend Educational Programmes/Trainings** | **Pre n1** | | **Post n2** | | **Total** | |
| Never | 20 | 18% | 10 | 11% | 30 | 15% |
| Sometimes | 64 | 56% | 51 | 57% | 115 | 57% |
| Most of the time | 24 | 21% | 27 | 30% | 51 | 25% |
| Always | 6 | 5% | 1 | 1% | 7 | 3% |
| **Total** | 114 | 100% | 89 | 100% | 203 | 100% |
| Chi² (d.f. = 3, n = 203) = 5.56; p = .135 | | | | | | |

Respondents were not grouped or divided in terms of ICU experience/position held in the ICU, additional qualifications in Critical Care Nursing or attending educational programmes/training. These were confounding variables that affected the percentage of correct responses (knowledge score outcome) from the respondents. In Table 2, a statistically significant p value <0.05 (p = 0,018) reveals that there is a relationship

between critical care nurses who had five years' or more experience and an increase in the mean percentage of correct responses across the three groups. This further reveals that the ICU experience of respondents had a moderate effect (Cohen's d = 0.67 medium) on the way critical care nurses respond to questions in the pre/post-test questionnaires.

**Table 2:** Relationships between the demographic variables and knowledge score outcome

| **Effect** | ***F*-value** | **d.f.** | **P** | **Cohen's d** |
|---|---|---|---|---|
| Pre/Post | 1,22 | 1; 193 | ,270 | |
| ICU Experience | 5,66 | 1; 193 | ,018 | 0,67 Medium |
| ICU Qualification | 1,09 | 1; 193 | ,297 | |
| Educational Programmes/Training | 2,92 | 1; 193 | ,089 | |

To determine the differences between pre-test and post-test means, we applied the t-test to each of the three groups in the study. Pre-test/post-test means, standard deviations, and differences for IG1, IG2 and the CG appear in Table 3.

Table 3 shows an increase in the mean percentage of correct responses at the post-test level (65,22) compared to the pre-test level (62,93) in IG1 and the difference at the pre/post-test level combined is not statistically significant (Difference = -2.29; t = -0.90; d.f. = 76; p=0.371; Cohen's d <0.20). The practical significance of combining educational intervention methods (PowerPoint presentation, printed copies of the guidelines, posters as reminders, and informal monitoring visits) is insignificant (Cohen's d <0.2), revealing a minor or trivial improvement in the respondents' knowledge. However, in IG2, there is a decrease in the mean percentage of correct responses at the post-test level (53,41) compared to the pre-test level (60,34) and the difference at the pre/post-test level combined is statistically significant (Difference = 6.93; t = 2.17; d.f. = 79; p=0.033; Cohen's d = 0.49). The practical significance of using a single educational intervention method (handing out printed copies of the guidelines) is small (Cohen's d = 0.49 small), ineffective and did not improve respondents' knowledge. Finally, in the CG, there is an increase in the mean percentage of correct responses at the post-test level (60,33) compared to the pre-test level (59,60) and the difference at the pre/post-test level combined is not statistically significant (Difference = -0.73; t = -0.15; d.f. = 44; p = 0.884; Cohen's d <0.20). The absence of an educational intervention had no practical significance (Cohen's d <0.20) in this group. Improvement in the mean percentage of correct responses at the post-test level in the CG could be related to one of the confounding variables such as the respondents' years of experience in the ICU.

**Table 3:** Pre/post-test differences within the three groups using the sample t-test

| Group | Pre/Post | N | Mean | S.D. | Differences | t | d.f. | p (d.f.=76) | Cohen's d |
|---|---|---|---|---|---|---|---|---|---|
| IG1 | Pre | 46 | 62,93 | 10,23 | -2,29 | -0,90 | 76 | 0,371 | <0.20 |
| | Post | 32 | 65,22 | 12,08 | | | | | |
| IG2 | Pre | 44 | 60,34 | 13,27 | 6,93 | 2,17 | 79 | 0,033 | 0,49 Small |
| | Post | 37 | 53,41 | 15,44 | | | | | |
| CG | Pre | 25 | 59,60 | 12,09 | -0,73 | -0,15 | 44 | 0,884 | <0.20 |
| | Post | 21 | 60,33 | 21,17 | | | | | |

As shown in Table 4, ANOVA indicates a significant variation in the distribution of mean percentages of correct responses between groups after the implementation of an educational intervention. There was no significant difference in the respondents' knowledge score at the pre-test level between the groups (d.f. = 2; F = 0.833; p = 0.437). At the post-test level, there was a significant difference in the knowledge score (d.f. = 2; F = 4.788; p = 0.011) after the educational intervention.

**Table 4:** Difference between the groups at the pre/post-test level using ANOVA

| Source of Variation | SS | d.f. | MS | F | p-value |
|---|---|---|---|---|---|
| Between Groups (Pre) | 234,875 | 2 | 117,437 | 0,833 | 0,437 |
| **Source of Variation** | **SS** | **d.f.** | **MS** | **F** | **p-value** |
| Between Groups (Post) | 2428,501 | 2 | 1214,251 | **4,788** | **0,011** |

## Discussion

Findings across the pre/post-test levels in the three groups show that the majority of the participants were female, as expected in a predominantly female profession. Most of the respondents had more than five years' working experience in the ICU and were in their fifties, denoting an ageing population of critical care nurses, which could play a major role in future ICU staffing. However, there were no respondents equal to or above the age of 60 years. Participants were trained formally as the majority either completed a postgraduate diploma/degree in Critical Care Nursing and received an additional qualification, and the majority indicated attending educational programmes/trainings to improve clinical practice.

There was an increase in the mean percentage of correct responses in IG1 after implementing the full educational intervention using the PowerPoint presentation, printed copies of guidelines, colour printed posters, and informal monitoring visits. However, a non-significant difference of a p value >0.05 (0.371) makes it difficult to accept a global comparison. Regardless, the outcome still agrees with other studies

(Jordan et al. 2017, 358; Munn et al. 2018, 83; Squires et al. 2014, 152) that combining methods to disseminate information could be more useful to ensure end-users are aware of, have access to, and understand the recommendations of guidelines.

The results from IG2 show a decrease in the mean percentage of correct responses (poor knowledge score outcome) after implementing an educational intervention using printed copies of guidelines only; even though it showed a significant difference of a p value <0.05 (0,033) and small effect size (Cohen's d = 0.49), it had no effect on improving the knowledge of the critical care nurses. One systematic review by Jordan et al. (2017, 358) indicates that printed educational materials are mostly used in the implementation of evidence-based guidelines in the ICU. In this study, printed copies of the guidelines alone as an educational intervention was insufficient to cause a significant increase in knowledge score. This illustrates that an educational intervention using only printed/written materials can fail to improve knowledge in nurses (Mockiene et al. 2011, 140).

Overall, the results of the post-test findings show a statistically significant knowledge score decline in IG2 in comparison with IG1 and CG. Statistical findings in this study are in keeping with a systematic review report that shows statistically or non-statistically significant differences may support findings in some educational intervention groups, while a few reports have shown differences that do not support any group or support only the control group (Cusack et al. 2018, 68). Implementing educational interventions has been shown to increase measures of knowledge among intervention groups in the short term (Cusack et al. 2018, 68, 77); hence, the retention of knowledge for a long time might have also been a problem in IG2. Knowledge retention in this study is connected to the method of implementing the educational intervention and the length of time from the intervention. Studies have shown that methods and the duration (ranging from one week to three months) of an educational intervention can affect knowledge retention (Badiei et al. 2016, 364; Bardosono et al. 2018, 128). Employing a follow-up approach to encourage the respondents to continuously engage with the educational intervention and a repeat post-test evaluation would be beneficial, but that was not the aim or objective of this study. Other factors include the population of critically ill patients, and the size and organisation of the ICU, which influence the effectiveness of educational interventions in disseminating information (Bero et al. 1998, 465; Jordan et al. 2017, 358).

Critical care nurses' ability to perform their functions may be limited by the following: inadequate coverage of some concepts during ICU programmes, limited discussion of concepts in clinical practice, a lack of clinical support and individual professional responsibility, high reliance on intuitive knowledge, a lack of collaborative practice and availability of medical expertise, and the limitations of clinical guidelines and protocols in the ICU (Pirret 2007, 145). Responses from the critical care nurses show that existing knowledge concurred with traditional practices or outdated information available as algorithms/protocols to liberate ventilated adult patients in public ICUs. An increase in

respondents' knowledge in the CG supports the existence of traditional practices, and reliance on instinctual knowledge and experience in the ICUs. Knowledge can be gained from work experience, but the critical care nurses' experience cannot wholly be relied on when caring for patients in the ICU. In the context of patient safety or patient-centred outcomes in the ICU, critical care nurses cannot solely rely on their experience in the ICU as a source of knowledge. A previous study in South Africa suggests it is crucial to implement continuous educational intervention programmes/methods to address knowledge gaps (Perrie et al. 2014, 14).

Finally, the findings in this study corroborate studies in South Africa that identified knowledge gaps among critical care nurses concerning EBGs in the ICUs (Demingo 2011, 98; Fischer 2014, 82; Perrie et al. 2014, 14). The study also agrees with other internationally published articles that using an educational intervention would impart knowledge about a concept and thus improve the knowledge of healthcare practitioners (Bero et al. 1998, 465; Grimshaw et al. 1995, 55; Jordan et al. 2017, 358; Mockiene et al. 2011, 140).

## Limitations of the Study

As the ICU is a busy and complex environment, it was not the best place to engage critical care nurses for a multi-phased research study. Although the respondents were engaged during their tea or lunchtime, some of them preferred a quiet moment during those periods and declined to participate, which was responsible for respondents' attrition in Phase Three. The pre- and post-test questionnaires only investigated and evaluated the knowledge of critical care nurses. The ventilator liberation practices of critical care nurses were not investigated, as these are often self-reported if an observational study is conducted. Due to the anonymous and voluntary nature of the questionnaire, it was not possible to follow up and ensure the exact respondents were included in the post-test, but this did not affect the quality of the responses or data analyses. Only selected educational intervention methods could be implemented and compared and a follow-up to determine the long-term effect of the educational intervention was not possible due to the limited scope of the study. However, recommendations in this regard were made.

## Recommendations

The study did not evaluate which of the educational intervention methods were more effective than the others, for instance, lectures, printed copies of the guidelines, reminders in the form of colour printed posters, or informal monitoring visits; and this should be further explored. However, an extended informal visit could have encouraged an educational session within the ICUs, and a future interventional study can be conducted to determine the knowledge, attitudes, and practices of the critical care nurses concerning ventilator liberation practices. A follow-up study using a second post-test can encourage the utilisation of the EBGs for the retention of knowledge.

In terms of formal education, the EBGs on ventilator liberation can be incorporated into one of the modules in the Critical Care Nursing programme or Critical Care Nursing refresher course. Otherwise, in terms of informal education, it can be taught during workshops and in-service training/education for Continuing Professional Development. Hospital management ought to encourage and make it compulsory that all critical care nurses in the ICU attend a seminar or workshop at least once a month to be aware of current evidence-based practice guidelines.

## Conclusion

The critical care nurses' lack of relevant and current knowledge on the current EBGs on ventilator liberation is of the utmost concern. Utilising an educational intervention to implement EBGs in a clinical setting can address the knowledge gap, but this is limited to the method of implementation. This study has identified that combining educational intervention methods such as PowerPoint presentations/lectures, printed copies of guidelines, colour printed posters and informal monitoring visits can be sufficient to disseminate information and inform knowledge and may be more effective than using printed copies alone. The implementation of in-service training or educational sessions in the ICU may encourage critical care nurses to engage with educational resources and in educational communications.

## Acknowledgements

The authors would like to thank the Department of Health, Eastern Cape Province, academic hospitals, and ICUs for the permission granted to conduct the study and express their appreciation to the critical care nurses and critical care experts who made the study a success.

## Author Contributions

All the authors contributed equally to the preparation of the manuscript.

## Funding

The study was supported by the Research Capacity Development Fund at the Nelson Mandela University and the National Research Foundation Scholarship Fund. The funding sources did not influence the research objectives, design, method, data collection, data analysis, interpretation of the data, empirical results, recommendation, writing of the report or the decision to publish an article.

## Conflict of Interest

The authors have no conflicts of interest to declare.

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