Received: 1 December 2021 | Revised: 24 February 2022 | Accepted: 25 February 2022

DOI: 10.1111/nicc.12768

RESEARCH ARTICLE

BACCN Nursing in Critical Care WILEY

Impact of staffing levels and resources of intensive care units on compliance to standard mechanical ventilator guidelines: A city-wide study in times of COVID-19 pandemic

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Funding information
No funding was provided for this study.

Abstract

Introduction: The COVID-19 pandemic has affected millions and resulted in a considerable strain on healthcare systems around the world. Intensive care units (ICUs) are reported to be affected the most because significant percentage of ICU patients requires respiratory support through mechanical ventilation (MV). This study examines the staffing levels and compliance with a ventilator care bundle in a single city in Pakistan.

Methods: A cross-sectional survey of 14 ICUs including medical and surgical ICUs was conducted through a self-structured questionnaire including a standardized ventilator care bundle. We assessed the compliance of ICU staff to ventilator care bundle and calculated the correlation between staffing patterns with compliance to this bundle.

Results: The unit response rate was 64% (7/11 hospitals). Across these seven hospitals, there were 14 functional ICUs (7 surgical and 7 medical). The Mean (SD) numbers of beds and ventilators were 8.14 (3.39) and 5.78 (3.68) while the average patient-to-nurse and patient-to-doctor ratio was 3: 1 and 5:1 respectively. The median ventilator care bundle compliance score was 26 (IQR = 21–28) out of 30, while in medical and surgical ICUs, median scores were 24 (IQR = 19–26) and 28 (IQR = 23–30) respectively. The perceived least compliant component was head elevation in ventilated patients. Correlation analysis revealed that 24 h a day, 7 days a week onsite cover of Advanced Cardiovascular Life Support certified staff was positively correlated with the ventilator care bundle score ($r_s = 0.654$, p value = .011). Similarly, 24-h cover of senior ICU nurses was significantly correlated with the application of chlorhexidine oral care ($r_s = 0.676$, p value = .008) while routine subglottic aspiration was correlated with the number of doctors ($r_s = 0.636$, p value = .014).

Conclusion: Our study suggests that ICUs in Peshawar are not well staffed in comparison with international standards and the compliance of ICUs with the ventilator care bundle is suboptimal. We found only a few aspects of ventilator care bundle compliance were related to nursing and medical staffing levels.

Relevance to clinical practice: Critical care staffs at most of the medical ICUs in Peshawar are not compliant with the standard guidelines for patients on mechanical ventilation. Moreover, the staffing levels at these ICUs are not in accordance with international standards. However, this study suggests that staffing levels may not be

the only cause of non-compliance with standard mechanical ventilator guidelines. There is an urgent need to design and implement a program that can enhance and monitor the quality of nursing care provided to mechanically ventilated patients. Lastly, nurse staffing of ICUs in Pakistan must be increased to enable high quality care and more doctors should be trained in critical care.

KEYWORDS
COVID-19, critical care, delivery of health care, intensive care units, patient care bundles

1 | INTRODUCTION

Tens of millions of confirmed cases of COVID-19 infection have been reported throughout the globe, including millions of deaths for reasons.[1] This viral disease leads to symptoms ranging from sore throat and cough to respiratory failure and multi-organ dysfunction.[2] Most patients that develop severe symptoms get admitted to different hospital settings, including the intensive care unit (ICU). As a result, there is a considerable strain on the available health resources, particularly critical care facilities. Pakistan is especially prone to the increasing burden of COVID-19 cases because of an already over-burdened healthcare system. Thus, it has become ever more significant to assess the present capacity of ICUs and staffing patterns to inform future health policy decisions. Studies have shown that staffing patterns in ICUs affect patient outcomes.[3,4]

Mechanical Ventilation (MV) is a significant life-saving intervention in ICUs. It is the indication that when the spontaneous ventilation of the patient is inadequate to sustain life. However, like other interventions, it also carries several risks for the patient. Ventilator-Associated Pneumonia (VAP) is defined as pneumonia that arises more than 48 h after endotracheal intubation.[5] VAP is the most commonly associated complication of MV, as about 9%–27% of patients who undergo MV acquire VAP.[6] In a multicentre surveillance study, Rosenthal et al.[7] reported the pooled mean VAP rate as 15.8 per 1,000 ventilator days. It is also the most serious complication of MV, as it contributes to an increase in patient mortality, morbidity, length of hospital stays, and financial cost.[8–10] Since VAP occurs in critically ill patients, it is difficult to determine the exact mortality of VAP. However, Melson et al.[11] have reported that VAP has an estimated attributable mortality rate of 13%.

Various international health agencies have recommended care bundles for the prevention of VAP. A bundle of care is a small set of evidence-based preventive measures that have been proved effective in improving patient outcomes if applied collectively and reliably.[12] Different bundles of care have been implemented in ICUs for the uniform and consistent delivery of care to every patient.

The components of most of these recommended VAP care bundles include elevation of the head of the bed, oral care and hygiene, proper drainage of endotracheal secretions, sedation vacation and spontaneous breath trials, Deep Vein Thrombosis (DVT) prophylaxis, and Peptic Ulcer Disease (PUD) prophylaxis.[13,14] These measures, although effective, can be a difficult task to follow in low-resource settings. It may be due to the increased burden on health care facilities and understaffed critical care units. This study aims to assess ventilator care bundle compliance and its relationship with staffing levels in a region of Pakistan.

What is known about this topic

- COVID-19 pandemic has affected the effective delivery of healthcare especially in ICUs because of the immense flow of critical patients which resulted in increased use of mechanical ventilators.
- Ventilator-Associated Pneumonia (VAP) is the most common complication in patients on mechanical ventilation. However, this risk can be minimized by following evidence-based guidelines grouped in the ventilator care bundle.

What this paper adds

- The current staffing levels of ICUs and compliance with the ventilator care bundle are not up to the international standards in a major city from the developing world.
- Low staffing level is not the solitary cause of suboptimal compliance with ventilator care bundle.
- Critical care nursing staff trained in Advanced Cardiac Life Support (ACLS) has been shown to be more compliant with the ventilator care bundle than those who are not trained.

2 | METHODS

2.1 | Study design

A cross-sectional survey was conducted to evaluate the adherence to Ventilator Care Bundle Guidelines in 14 ICUs from seven teaching hospitals of Peshawar, Pakistan in December, 2020. The Society of Undergraduate Medical Research Committee granted the study's Ethical approval (SUMR: ICU 002/2018). Verbal permission was obtained from the in-charge of each ICU before distribution of the paper surveys. Confidentiality was assured and no names of institutions or individuals were recorded.

2.2 | Sampling

A comprehensive list of all the Registered Teaching Hospitals in Peshawar was obtained from the Pakistan Medical and Dental Council (now Pakistan Medical Commission) website that regulates the teaching hospitals all over Pakistan. Out of a total 11 registered teaching hospitals in Peshawar with ICUs, seven were included in our study. Four registered teaching hospitals, including two military hospitals, could not be included because permission was not granted by the hospital administration. Our team members then verified the availability of intensive care facilities at each hospital through their websites. If this information was not available online, a team member called the hospital and confirmed ICU availability.

2.3 | Data collection

For data collection, the authors visited each teaching hospital, and each visit took approximately 90 min. Verbal permissions were obtained from the in-charge of each intensive care unit before inviting the staff on duty to fill in a hand filled questionnaire. At least two doctors, two nurses and the shift in-charge of ICU were invited to complete the questionnaire. To control any potential bias and maintain the authenticity of the survey, several measures were taken. Firstly, questionnaires were handed over to the staff members to fill in and collection was scheduled for later to minimize the possibility of peer pressure. Secondly, all response sheets were blinded to ensure that staff members reported accurately the practices happening in a particular unit. Thirdly, to decrease the risk of subjective bias, data were not always collected from a single shift time but at different times from different centres and more than five staff members were invited to fill in the questionnaires in large units. The questionnaires were then checked for any discrepancies, outliers and coherence; the median scores obtained and then were entered in a single questionnaire. The data was coherent and no outliers were reported. Therefore, the analysis included one filled questionnaire from each ICU. The questionnaire regarding facilities and staffing was only filled by the shift in charge.

2.4 | Instruments

Our questionnaire comprised of three major sections; the first section was to assess the capacity of ICU including the availability of material and human resources including the number of available doctors, nurses, and specialized ICU staff. The second section consisted of a 6-item ventilator care bundle questionnaire which was originally developed and used by Institute for Healthcare Improvement (IHI) in the United States, but then it was also introduced into the United Kingdom by the Modernisation Agency and was widely accepted by various healthcare bodies including the National Patient Safety Agency. The preliminary version of the ventilator bundle care had five items but the latest one United Kingdom recommended version has six items. According to the scale, the maximum and minimum attainable score was 30 and 5 respectively. A five-point Likert scale was developed, which was interpreted as 1 = Never (applicability of a particular practice), 2 = Less than 50% of times, 3 = More than 50% of times, 4 = Most of the time/more than 85% of times and 5 = Always or 100% of times. The third section of the questionnaire consists of a few additional questions that tend to assess the basic facilities and practices carried out in the ICU; such as availability of family counselling room, educational sessions for staff, arterial blood gases (ABGs) test and confirmatory X-ray after putting a patient on a ventilator.

2.5 | Questionnaire

Ventilator care bundle.

2.6 | Scoring method

(1 = Never; 2 = Less than 50% of times; 3 = More than 50% of times; 4 = More than 85% of times; 5 = All the time)

Components of ventilator care bundle	1	2	3	4	5
Ventilated patients cared for in a head-up position					
Routine oral care with chlorhexidine at least twice in 24 h					
Peptic ulcer prophylaxis with proton pump inhibitors					
Daily sedation hold and assessment of readiness to extubate					
Venous thromboembolism prophylaxis					
Routine subglottic aspiration					

2.7 | Statistical analysis

During data collection, research assistants entered the data on paper and made sure that there is no missing data which was then reviewed by the study leader for any potential errors. Data available on paper was then entered into Social Pack of Statistical Sciences (SPSS, version 23.0 IBM Corp., Armonk, NY) software by research assistants and then it was re-checked by two other members for any entry errors. Categorical variables were calculated in percentages while means and standard deviations were reported for continuous variables. The ventilator care bundle scores were reported as medians and interquartile range (IQR) and non-parametric tests were performed for further analysis. Spearman correlation analysis was executed to find out the relationship between various variables. The analysis was performed at a 95% confidence interval and p value set at .05.

3 | RESULTS

3.1 | Unit characteristics

The unit response rate was 64%, as 11 different tertiary care hospitals across Peshawar, Pakistan were approached among which only seven hospitals contributed to the study. Across the seven hospitals, data from 14 ICUs were included consisting of seven medical and seven surgical (including neurosurgery and cardiothoracic surgery). Overall, 114 beds were available in these 14 ICUs, of which 90 beds had ventilation capacity. The average patient-to-registered nurse was 3:1 while patient to ICU-specialized doctor was 5:1. There was a total of 66 doctors working across these ICUs; however, out of these, only 21 (32%) were formally trained in critical care medicine while other doctors were residents and foundation year trainees. A total of 64 nurses were working in these ICUs of among which only 38 (59%) were registered nurses and formally trained in critical care nursing while other staff comprised of assistant and student nurses. Table 1 shows the unit characteristics of the present study.

Additionally, five ICUs had Advanced Cardiovascular Life Support (ACLS) certified staff, while 11 ICUs had Basic Life Support (BLS) certified staff available 24 h a day and 7 days a week. Only three ICUs had 24 h a day, 7 days a week onsite cover of at least one consultant doctor and one senior ICU nurse. Only five out of 14 ICUs had respiratory therapists, while the other nine ICUs had no trained respiratory therapist available. Hand sanitizers for each ventilator-capable bed were present in only 84% of the ICUs. A private family counselling room was only available in only four ICUs (two surgical and two medical). Monthly educational sessions for doctors, nurses, trainees and supporting staff were only regularly organized at 10 out of 14 ICUs (six surgical and four medical).

TABLE 1 Baseline characteristics including human resources

Characteristic	Frequency	Mean ± SD per ICU
Total number of beds	114	8.14 ± 3.39
Total number of ventilators	90	6.43 ± 3.83
Total number of doctors including trainees	66	4.71 ± 3.83
Total number of ICU qualified doctors	21	1.50 ± 1.16
Total number of Nurses including student and assistant nurses	64	4.57 ± 2.41
Total number of registered ICU nurses	38	2.71 ± 3.51
Total number of respiratory therapists	9	-

3.2 | Compliance with ventilator care bundle

The ventilator care bundle questionnaire score ranged from 16 to 30, with a median of 26 (IQR = 21–28). The lowest and highest scores for medical ICUs were 16 and 28; median = 24 (IQR = 19–26), while for surgical ICUs, lowest and highest scores were 22 and 30; median = 28 (IQR = 23–30). Surgical ICUs seem to be more compliant with the components of the ventilator care bundle than the medical ICUs as one medical and four surgical ICUs scored higher than the median score, however, the results were not statistically significant (p value = .266). Three components of the ventilator care bundle were less compliant in medical than surgical ICUs. These were "ventilated patients cared for in a head-up position," "routine oral care with chlorhexidine at least twice in 24 h" and "peptic ulcer prophylaxis with proton pump inhibitors." Table 2 shows the overall and individual median ventilator care bundle scores of medical and surgical ICUs.

Statistical analysis was performed to discover if a significant correlation between ventilator care bundle score and other characteristics existed. The compliance with ventilator care bundle was positively correlated with the presence of ACLS qualified staff (24 h a day) (r_s =0.654, p value = .011) and with units having a higher number of ventilated beds (r_s =0.644, p value = .013). It was discovered that the availability of 24 h a day, 7 days a week onsite cover of senior ICU nurses was positively correlated with chlorhexidine oral care (r_s =0.676, p value = .008) and sending the first sample for ABGs within 10 min of starting a mechanical ventilator (r_s = 0.808, p value = <.001) while routine subglottic aspiration was positively

TABLE 2 Ventilator care bundle questionnaire and median scores of individual items

Components of ventilator care bundle	Overall median score (IQR) N = 14	Medical ICUs median score (IQR) N =7	Surgical ICUs median score (IQR) N =7
Ventilated patients cared for in a head-up position.	5 (2.75–5)	4 (2–5)	5 (5–5)
Routine oral care with chlorhexidine at least twice in 24 h.	5 (3.75–5)	4 (1–5)	5 (5–5)
Daily sedation hold and assessment of readiness to extubate.	5 (4.25–5)	5 (2–5)	5 (5–5)
Peptic ulcer prophylaxis with proton pump inhibitors.	5 (3.75–5)	4 (2–5)	5 (5–5)
Venous thromboembolism prophylaxis.	5 (3.50–5)	5 (4–5)	5 (1–5)
Routine subglottic aspiration.	5 (3.00–5)	5 (1–5)	5 (3–5)

Abbreviation: IQR, interquartile range.

correlated with the total number of doctors (r_s =0.636, p value = .014). DVT prophylaxis was positively correlated with increased registered nurses' presence (r_s =0.610, p value = .021). No other significant correlation was found between the ventilator care bundle score and other variables.

4 | DISCUSSION

Critical care is an essential part of healthcare systems throughout the world. However, it requires high resource allocation due to the increased costs of training staff and for equipment. Critical care has assumed an even more crucial role with the advent of the COVID-19 pandemic. Affecting millions across the globe, it has put further strain on critical care services, particularly in Lower-middle Income Countries (LMIC). Carter and Notter have reported the inequality that pervades global healthcare systems and how lack of resources has disproportionately affected healthcare systems in these LMIC.[15]

Also, staffing levels are an important factor in quality healthcare delivery. Harvey and Trudgill have shown that fewer beds per physician are associated with decreased patient mortality.[4] Griffiths et al. have shown that adequate registered nurse staffing also influences patient outcomes, and similar results have been reported by others.[16] Our results showed that both overall staffing levels and the number of ICU trained specialists were suboptimal. In a nationwide survey of critical care services in Pakistan, Hashmi et al. have also reported similar results, highlighting a lack of trained critical care staff in ICUs in Pakistan.[17] In contrast, Haniffa et al.[18] in Sri Lanka, a lower-middle-income country similar to Pakistan, reported better nurse staffing levels with a nurse-to-patient ratio of 1:1 in 87.9% of the ICUs included and an extensive critical care network. However, Murthy et al. have reported a paucity of data regarding critical care in low-income countries and a need to develop a national database to evaluate healthcare system performance.[19]

The use of Care Bundles in healthcare settings to prevent or manage different health conditions has recently become widespread. One important reason for this may be that Care Bundles are easily applied collectively in a particular healthcare setting and may also be used as an audit tool to assess the quality of care. Based on numerous reports in the literature evaluating the effectiveness of Care Bundles, there is a strong case for their extensive implementation in critical care medicine.[12]

The original version of the IHI ventilator care bundle had five fundamental components. Three components of this bundle target the VAP, while two components address counteraction of stress ulcers and thrombolytic problems. The current National Health Service (NHS) recommendations also add subglottic aspiration to the ventilator care bundle.[20] This bundle has been extensively implemented by numerous intensive care settings to decrease the incidence of VAP.[21] Studies have shown that adherence to ventilator care bundle components can independently and collectively assist in the prevention of VAP.[22,23] A European study supported the evidence that the use of ventilator care bundles has a significant role in controlling the occurrence of VAP.[18] A study led by Scottish researchers found that when the adherence to the ventilator care bundle was increased to 80% (initially 40%), the incidence of VAP significantly reduced from 6.9/1000 to 1.0/1000 and the number of ventilator days was reduced from 7.8/1000 to 1.4/1000.[24]

Two studies, conducted in the US and Spain, reported that keeping the ventilator patients in a head-up position significantly decreases the occurrence of VAP and associated adverse outcomes.[25,26] However, in our study "Ventilated patients cared for in a head-up position" was the least compliant component in medical ICUs with median score of 4 (2–5). Practicing a standard ventilator weaning protocol and daily assessment of readiness to extubate by stopping sedation has also been proven as a measure to prevent VAP. This practice has been shown to lead to swift ventilator weaning, which leads to fewer days in the ICU and ultimately decreases the risk of contracting a healthcare associated infection.[27]

A meta-analysis of 13 randomized clinical trials concluded that routine subglottic drainage decreases the chances of VAP by reducing the number of days in the hospital and increasing the time to the first VAP episode.[28] Similarly, a high-profile meta-analysis carried out on 12 studies published in Lancet Infectious Diseases reported that the routine use of chlorhexidine for oral care is effective in the prevention of VAP (Relative Risk: 0.72, p value = .02).[29] However, two recent meta-analyses concluded that oral chlorhexidine may increase mortality in mechanically intubated patients, and fails to prevent VAP.[30,31] Dale et al.[32] performed a stepped-wedge cluster-randomized controlled trial (CHORAL Trial) to examine this hypothesis. They de-adapted the standard practice of chlorhexidine oral wash in the intervention group and replaced it with an evidence-based multi-component oral care bundle which comprised of twice daily (morning and evening) oral assessment and tooth brushing; mouth moisturization, lip moisturization with additional secretion removal 4-hourly. They concluded that there was no statistically significant difference in these two groups in terms of mortality outcomes, and time to extubation was similar. Routine oral care is recommended because of its feasibility and cost-effectiveness, in addition to its proven efficacy in the literature.[33] Similar results regarding oral care have been reported by O'keefe-McCarthy.[34]

All the components of the ventilator care bundle have increased efficacy if applied collectively, as opposed to being applied individually. Al-Thaqafy et al. have reported the ventilator care bundle compliance rate at an ICU in KSA to be as high as 90%.[35] A similar study by Wigmore and Sethuraman reported a ventilator care bundle compliance rate of 32%,[36] while Bird et al. have reported a ventilator care bundle compliance rate of 53%–63%.[37] This shows that compliance rates in the literature vary greatly. In our study, the highest ventilator care bundle compliance rate was among the Surgical ICUs, with a median (IQR) score of 28 (7). This score can be compared with the score of medical ICUs, which was only 24 (7). The overall median (IQR) score was 26 (7) out of a total of 30. Hamishehkar et al. in an observational study conducted at Tabriz, Iran reported a low ventilator care bundle adherence (41.2%) even after educating the ICU staff.[38]

Lastly, McMillan and Hyzy have shown that introducing quality improvement strategies in the systems of care, including bundles of care, can positively affect patient outcomes.[39] The Keystone ICU

project was an ambitious quality improvement project undertaken in 2003 by John Hopkins University School of Medicine and included 108 ICUs from 77 hospitals across Michigan, USA. This project aimed to reduce Central-line associated bloodstream infections (CLABSI) and VAP and introduce a culture of safety in the ICUs. By 2005, the project had reported considerable improvement in patient safety culture, CLABSI rates and adherence to ventilator care interventions.[40] This further emphasizes the need for proper staffing and increased investment in critical care services to improve patient outcomes. Staff education and training is also a vital aspect of quality improvement. However, as Hamishehkar et al.[38] has shown, staff education should be accompanied by other quality improvement strategies such as proper audit and supervision of the staff regarding adherence to care bundles and creating a culture of patient safety.

5 | LIMITATIONS

More than half (64%) of the ICUs of the city were included in the current study but for generalization of results data from other ICUs is also required. Self-report questionnaires were used in this study. This method has limitations which may affect the reliability and validity of measurement. There may be an external bias caused by social desirability or approval, such as possible coercion of staff to complete surveys if asked by the manager. Using a single questionnaire from each ICU unit by summarizing the responses of participants and not involving every staff member in the survey may also affect the validity of our results. In future, there is a need to design an observational study to determine the adherence to standard practices rather than relying on staff's perceived responses.

6 | CONCLUSION

Our study showed ICUs in the Peshawar region of Pakistan are poorly staffed in comparison to similar settings in the region and around the world. Our results also suggest that compliance with ventilator care bundles is suboptimal, but further robust observational research is required. There is an urgent need for planning and resource allocation to ICUs to enhance the quality of patient care delivered. Moreover, the lack of compliance with the ventilator care bundle may impact patient care but it is not solely related to staffing levels. This problem needs to be addressed by an intensive VAP bundle education program for the ICU staff in addition to increasing the nursing staffing levels.

ETHICAL APPROVAL STATEMENT

Society of Undergraduate Medical Research core committee granted the study's ethical approval (SUMR: ICU 002/2018).

PATIENT CONSENT STATEMENT

Patients were not directly involved in this so this is not applicable.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER RESOURCES

Not applicable.

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How to cite this article: Rashid K, Ansar F, Khan Y, et al. Impact of staffing levels and resources of intensive care units on compliance to standard mechanical ventilator guidelines: A city-wide study in times of COVID-19 pandemic. *Nurs Crit Care*. 2022;1-7. doi:10.1111/nicc.12768