INTRODUCTION

Determining the optimal timing of weaning from mechanical ventilation (MV) and of extubation continues to be a challenge in ICUs. In pediatrics and neonatology, there is no strong evidence of an effective and standardized method for MV weaning; nor are there any validated tests or criteria that are considered reliable means of determining patient readiness for extubation.

A variety of strategies and criteria for weaning and extubation have been described in the literature, including evaluation of ventilatory parameters, clinical/biochemical criteria, and predictive indices of extubation that can be followed by or combined with spontaneous breathing trials (SBTs) or gradual withdrawal from ventilatory support. It is important to standardize the criteria and methods of evaluating these variables, to identify accurate, reproducible predictors of weaning from MV and extubation. Few studies have evaluated the weaning and extubation practices in pediatric and neonatal ICUs (PICUs and NICUs, respectively).

To our knowledge, there have been no comprehensive studies characterizing the clinical practices for weaning and extubation in NICUs and PICUs. Therefore, this survey aims to describe the characteristics related to the application of protocols, methods, and criteria used in the process of MV weaning and extubation in such ICUs in Brazil.

METHODS

Study design and population

This was a cross-sectional analytical survey, designated the Weaning Survey-Brazil, involving a nationwide sample of 693 ICUs identified from the National Registry of...
Health Care Facilities of the Brazilian National Ministry of Health. Of those 693 facilities, 337 are NICUs, 323 are PICUs, and 33 are mixed neonatal/pediatric units (NPICUs).

To define our study sample, the number of ICUs was calculated so that the survey would represent all of Brazil. The sample size calculation considered a significance of \( \alpha = 0.05 \) and a statistical power of \( 1 - \beta = 0.95 \), with a minimum recommended sample in each state/region according to the sample of ICUs registered with the National Registry of Health Care Facilities, resulting in a minimum sample size of 82 ICUs.

We obtained e-mail addresses or telephone numbers for professionals to contact at 298 ICUs by consulting the membership list of the Brazilian Association of Intensive Care Medicine and by making telephone calls to the hospitals whose ICUs were registered with the National Registry of Health Care Facilities (Figure 1). The ICU professionals contacted were the coordinator or intensivist in charge of each ICU (physical therapist/respiratory therapist, physician, or nurse).

**Development of the survey**

The survey was developed by the main researchers, who were experts in intensive care, and was based on a review of relevant literature and other surveys. A pilot study was conducted with 10 practitioners representing each ICU type (NICUs, PICUs, and NPICUs) and from each profession, to allow correction for potential confounding factors in the items on the questionnaire. Using Google Forms, a web-based survey tool, we developed a survey questionnaire containing 23 questions, divided into 11 subscales, with mandatory responses.

We collected data on the MV weaning and extubation processes in the neonatal and pediatric age groups. The issues addressed were aspects of ICU practice regarding the application of weaning protocols; weaning/
were considered significant.

The initial contact with eligible respondents was made through a personalized e-mail containing a link to the electronic survey, as well as an invitation to take part in the survey, and the authorization form was sent to the coordinator or intensivist in charge of each ICU (physical therapist/respiratory therapist, physician, or nurse). Only one of those was a representative of the ICU. After the initial invitation, reminders were sent and phone calls were made until the minimum sample size was reached for each state/region.

**Ethical considerations**

This study was approved by the Research Ethics Committee of the Federal University of Uberlândia (Reference no. 1.301.015). Participation was voluntary, and the survey included those ICUs for which the authorization form was signed by and received from the coordinator or intensivist in charge.

**Statistical analysis**

Multiple-response categorical variables were compared by using chi-square tests. Continuous variables were evaluated for normality with the Kolmogorov-Smirnov test and were compared by using the Kruskal-Wallis test followed by the Games-Howell post hoc test. The results are expressed as absolute and relative frequencies or as medians and interquartile ranges (IQRs). Multiple comparisons of proportions were performed in the program R (R Development Core Team, 2017). For all analyses, values of p < 0.05 were considered significant.

**RESULTS**

Of the 298 questionnaires sent, 156 were completed and returned, corresponding to a response rate of 52.3%. However, 10 questionnaires were excluded, either because of duplication (two questionnaires received from the same ICU) or because the authorization form was not received (Figure 1). Therefore, the final sample comprised 146 questionnaires: 72 (49.3%) received from NICUs; 52 (35.6%) received from PICUs; and 22 (15.1%) received from NPICUs. Our survey included ICUs in all 26 states and in the Federal District, across all regions of the country, the response rates ranging from 13.0% to 100.0% for each state and from 16.0% to 36.3% for each region.

Of the 146 respondents, 84 (57.5%) reported that weaning protocols were available for only 54: continuous positive airway pressure (CPAP) of 5 cmH$_2$O in 7 (13.0%); pressure-support ventilation (PSV) at a median of 10.0 cmH$_2$O (IQR, 8.0-12.0 cmH$_2$O) together with positive end-expiratory pressure (PEEP) at a median of 5.0 cmH$_2$O (5.0-5.5 cmH$_2$O), in 43 (79.6%); and a T-piece connected to an oxygen source with an FiO$_2$ of 0.4, in 4 (7.4%). Regarding the median SBT duration, there was a significant difference among the ICU profiles (p = 0.004), as well as significant differences between them: 30.0 min (IQR, 20.0-60.0 min) in the NICUs vs. 67.5 min (IQR, 30.0-120.0 min) in the PICUs (p = 0.001); and 45.0 min (IQR, 30.0-60.0 min) in the NPICUs (p < 0.050 vs. the NICUs and PICUs). However, the median SBT duration did not differ significantly among the three ventilation modes (p = 0.053): 15.0 min (IQR, 10.0-30.0 min) for CPAP vs. 60.0 min (IQR, 30.0-120.0 min) for PSV+PEEP vs. 60.0 min (IQR, 20.0-75.0 min) for the T-piece trial. The time frame considered for extubation failure and other variables collected are presented in Table 2. The ventilation modes used during weaning are shown in Figure 2. The ventilation mode most often employed during the weaning of pediatric patients from MV (in PICUs and NPICUs) was the combination of synchronized intermittent mandatory ventilation (SIMV) and PSV, shifted to PSV alone before extubation. For neonatal patients, there was no one mode that was predominant, in the NICUs or the NPICUs.

Among the NICUs, the main causes of extubation failure reported were apnea, in 68.1%, respiratory distress, in 54.2%, and clinical hemodynamic, infectious, or neurological worsening, in 34.7%. Among the NPICUs, the main causes of extubation failure reported for the neonatal patients were respiratory distress, in 59.1%, clinical worsening, in 59.1%, and apnea, in 50.0%. Among the PICUs, the main causes of extubation failure reported were upper airway obstruction, in 59.6%, neurological or neuromuscular disease, in 51.9%, and respiratory distress, in 44.2%. Among the pediatric patients admitted to the NPICUs, the most common cause of extubation failure was respiratory distress, in 59.1%, followed by upper airway obstruction, in 45.5%, and prolonged sedation time, in 36.4%.

The three types of ICU were compared in terms of the strategies employed in protocolized and non-protocolized MV weaning, as well as the SBT ventilation modes and other variables (Table 3). The proportion of ICUs using weaning protocols was comparable between the NICUs and NPICUs (52.8% and 57.1%, respectively), whereas it was higher (65.4%) among the PICUs. Regarding the methods of liberation from MV, 60.5% of the NICUs and 50.0% of the NPICUs reported using standardized gradual withdrawal from ventilatory...
support, whereas SBT was the most common method used in most (53.0%) of the PICUs and in 41.7% of the NPICUs, compared with 29.0% of the NICUs. Among the ICUs which did not report using weaning protocols, a gradual withdrawal from ventilatory support based on clinical judgment was employed in 67.6% of the NICUs and 77.8% of the NPICUs, compared with only 16.7% of the PICUs. The proportion of ICUs using the SBT strategy after withdrawal from ventilatory support was highest (83.3%) among the PICUs (Table 3).

Table 4 shows a comparison between the ICUs with protocolized weaning and those without, in terms of weaning and extubation criteria, as well as extubation failure and its characteristics. Some significant differences were identified.

### DISCUSSION

To our knowledge, the Weaning Survey-Brazil is the first study to evaluate MV weaning practices in the pediatric and neonatal age groups in Brazil. We found that the clinical practice for weaning from MV and extubation varies according to the age group served by the ICU.

Our results indicate that most of the participating ICUs (57.5%) employ weaning and extubation protocols, and that such protocols are employed most often in the PICUs. Overall, the most common method of weaning from MV was found to be gradual withdrawal from ventilatory support, which was employed in 49.7% of the ICUs surveyed, especially in the NICUs and NPICUs, although most of the PICUs employed the SBT method.

Protocols are useful for conducting safe, efficient MV weaning, reducing unnecessary or harmful variations in the process. However, we found that the MV weaning protocols employed differed from one ICU to another, demonstrating that there are no standardized protocols in the fields of pediatrics and neonatology. Although such protocols should be used as a complement to clinical judgment, gradual withdrawal from ventilatory support, based on clinical judgment, is the weaning approach more frequently applied in neonatal and pediatric patients, extubation being performed after the minimal ventilation parameters have been reached or the patient has undergone a successful SBT. There is no consensus on which MV weaning method is the best, and it is possible that not all patients require gradual weaning.
Two previous studies carried out in PICUs in Europe showed that weaning protocols were either available in few (22%) of the PICUs or were seldom used, being employed in only 9%. Regarding the weaning methods, those same studies indicated that the weaning methods adopted varied according to clinical preferences and that SBTs were applied in 44%. A prospective cohort evaluating PICUs in the United States found that most (62%) use SBT as a method of weaning from MV, similar to the 83.3% found in the present study. However, the proportion of NICUs using weaning protocols has varied across surveys carried out in different countries, where an SBT was either not part of the weaning practice or was rarely used.

In general, SBTs are applied as an early means of determining whether a patient is capable of spontaneous autonomous breathing and is ready to be extubated. Studies involving pediatric patients and neonatal patients suggest that SBTs are applicable in those age groups, showing that the trials have high sensitivity for predicting successful extubation. In the present study, we found that the SBT ventilation mode most often employed was CPAP in the NICUs, whereas it was PSV+PEEP in the PICUs. Ventilatory support and SBT duration varied regardless of the method chosen, as has been described in previous studies conducted in other countries.

RSBI: rapid shallow breathing index; MV: mechanical ventilation; and SBT: spontaneous breathing trial.

**Table 2.** Criteria for weaning from mechanical ventilation and extubation in neonatal and pediatric ICUs in Brazil.

| Criteria and other variables                                      | n (%)  |
|-------------------------------------------------------------------|--------|
| **Weaning and extubation readiness criteria (N = 146)**          |        |
| Clinical criteria                                                 | 11 (7.5) |
| Clinical and biochemical criteria                                 | 101 (69.2) |
| Clinical criteria, biochemical criteria, and predictive indices  | 33 (22.6) |
| Clinical criteria and predictive indices                          | 1 (0.7) |
| **Biochemical criteria (n = 134)**                               |        |
| Arterial blood gas analysis                                       | 129 (96.3) |
| Other                                                             | 80 (59.7) |
| **Predictive indices (n = 33)**                                   |        |
| RSBI                                                              | 14 (42.4) |
| MV parameters                                                     | 11 (33.3) |
| MIP, MEP, or both                                                 | 6 (18.2) |
| SBT                                                               | 4 (12.1) |
| PaO2/FiO2 ratio                                                   | 4 (12.1) |
| Other                                                             | 15 (45.4) |
| **Time frame considered for extubation failure (N = 146)**       |        |
| 24 h                                                              | 39 (26.7) |
| 48 h                                                              | 68 (46.6) |
| 72 h                                                              | 14 (9.6) |
| Undefined                                                         | 25 (17.1) |
| **Number of extubation attempts (N = 146)**                      |        |
| Most patients are successfully extubated on the first attempt     | 130 (89) |
| Most patients require up to 3 attempts                            | 13 (8.9) |
| Most patients require more than 3 attempts                       | 0 (0.0) |
| Could not inform                                                  | 3 (2.1) |
| **Use of a weaning protocol after extubation failure on the first attempt (N = 146)** |        |
| No                                                                | 94 (64.4) |
| Yes                                                               | 41 (28.1) |
| In some cases                                                     | 11 (7.5) |
| **Registration of clinical indicators (N = 146)**                 |        |
| Time on MV                                                        | 139 (95.2) |
| Cause of extubation failure                                       | 88 (60.3) |
| Weaning time                                                      | 40 (27.4) |

RSBI: rapid shallow breathing index; MV: mechanical ventilation; and SBT: spontaneous breathing trial.
The impact of applying MV weaning protocols is typically evaluated by clinical indicators such as the time on MV, weaning time, and extubation failure rate. In the present survey, the time on MV was an indicator recorded in all ICUs, although weaning time was not commonly recorded. In one systematic review, it was suggested that weaning protocols decrease the time on MV in children. However, there is still insufficient evidence to support that suggestion, especially as it applies to neonates.

In the present survey, we found that the majority of patients were successfully extubated on the first attempt, regardless of whether the ICU employed protocolized weaning or not. We also found that ICU teams that did not apply weaning protocols also did not apply protocols after extubation failure. Extubation failure is defined as the need for reintubation within the first 24-72 h after extubation. Many of the ICUs evaluated in the present survey defined extubation failure as a need for reintubation within the first 48 h after extubation. That definition was more often used in the PICUs than in the NICUs and NPICUs.

The causes of extubation failure were more often recorded in the PICUs and in the ICUs that employed weaning protocols. Obstruction of the upper airways was the most common cause of extubation failure, as has been reported in previous studies involving pediatric patients. Among the neonates, apnea was the most commonly reported cause of extubation failure, as has also been reported previously.

The use of a combination of subjective and objective criteria might have greater predictive accuracy in assessing fitness for liberation from ventilatory support and has provided major insights into the mechanisms of weaning failure. Clinical and laboratory criteria, as well as the application of predictive indexes, can assist in assessing readiness for extubation. In our survey, we observed that 69.2% of the ICUs evaluated were using clinical and laboratory criteria, mainly the arterial blood gas data, to evaluate patient readiness for weaning and extubation. The predictive index most often employed was the rapid shallow breathing index. However, when asked about the predictive indices employed, 33.3% of the respondents reported using the MV parameters and 45.4% reported using other criteria, which shows that there is a lack of knowledge regarding the correct terms related to the predictive indices.

Corroborating our findings, previous surveys conducted in other countries have found that the criteria most often evaluated to determine extubation readiness were clinical criteria in PICUs, whereas the criteria most often evaluated in NICUs were ventilation parameters (in 98%), blood gas analyses (in 92%), and clinical...
Table 3. Comparison among ICUs serving different age groups, in terms of ventilator weaning and extubation practices, in Brazil.

| Practice                                                        | NICU (n = 75) | PICU (n = 52) | NPICU (n = 22) |
|-----------------------------------------------------------------|---------------|---------------|----------------|
| **Use of a weaning protocol, %**                                |               |               |                |
| Yes                                                             | 52.8<sup>aA</sup> | 65.4<sup>aA</sup> | 57.1<sup>aA</sup> |
| No                                                              | 47.2<sup>aA</sup>  | 34.6<sup>aA</sup>  | 42.9<sup>aA</sup>  |
| **Weaning protocol employed, %**                                |               |               |                |
| Standardized gradual withdrawal from ventilatory support       | 60.5<sup>aA</sup> | 29.4<sup>aAB</sup> | 50.0<sup>aAB</sup> |
| SBT with or without daily interruption of sedation            | 29.0<sup>aA</sup> | 53.0<sup>aA</sup>  | 41.7<sup>aA</sup>  |
| Other                                                           | 10.5<sup>aA</sup> | 17.6<sup>aA</sup>  | 8.3<sup>aA</sup>   |
| **Non-protocolized weaning strategies, %**                     |               |               |                |
| Gradual withdrawal from ventilatory support based on clinical judgment | 67.6<sup>aA</sup> | 16.7<sup>bA</sup>  | 77.8<sup>aA</sup>  |
| SBT after parameter reduction                                   | 26.5<sup>aA</sup> | 83.3<sup>aA</sup>  | 22.2<sup>bA</sup>  |
| Other                                                           | 5.9<sup>bA</sup>  | ---            | ---             |
| **Ventilation modes during SBT, %**                            |               |               |                |
| CPAP                                                            | 27.8<sup>aA</sup> | 6.7<sup>bA</sup>  | ---            |
| PSV+PEEP                                                       | 66.7<sup>aA</sup> | 86.7<sup>aA</sup> | 83.3<sup>aA</sup> |
| T-piece                                                        | 5.5<sup>aA</sup>  | 6.7<sup>aA</sup>  | 16.7<sup>aA</sup> |
| **Weaning and extubation readiness criteria, %**                |               |               |                |
| Clinical criteria                                               | 4.1<sup>bA</sup>  | 13.7<sup>bA</sup> | 4.5<sup>bA</sup>  |
| Clinical and biochemical criteria                               | 73.6<sup>aA</sup> | 58.9<sup>aA</sup> | 81.8<sup>aA</sup> |
| Clinical criteria, biochemical criteria, and predictive indices | 22.3<sup>aA</sup> | 27.4<sup>aA</sup> | 13.7<sup>aA</sup> |
| Clinical criteria and predictive indices                        | ---            | ---            | ---            |
| **Time frame considered for extubation failure, %**             |               |               |                |
| 24 h                                                            | 27.8<sup>aA</sup> | 23.1<sup>bA</sup> | 31.8<sup>aA</sup> |
| 48 h                                                            | 36.1<sup>aA</sup> | 59.6<sup>bA</sup> | 50.0<sup>aA</sup> |
| 72 h                                                            | 12.5<sup>aA</sup> | 5.8<sup>bA</sup>  | 9.1<sup>aA</sup>  |
| Undefined                                                       | 23.6<sup>aA</sup> | 11.5<sup>aA</sup> | 9.1<sup>aA</sup>  |
| **Use of a weaning protocol after extubation failure on the first attempt, %** |               |               |                |
| Yes                                                             | 26.4<sup>aA</sup> | 26.9<sup>aA</sup> | 36.4<sup>aA</sup> |
| No                                                              | 65.3<sup>aA</sup> | 65.4<sup>aA</sup> | 59.1<sup>aA</sup> |
| In some cases                                                   | 8.3<sup>aA</sup>  | 7.7<sup>aA</sup>  | 4.5<sup>aA</sup>  |
| **Time on MV recorded, %**                                     |               |               |                |
| Yes                                                             | 94.4<sup>aA</sup> | 96.2<sup>aA</sup> | 95.5<sup>aA</sup> |
| No                                                              | 5.6<sup>aA</sup>  | 3.8<sup>aA</sup>  | 4.5<sup>aA</sup>  |
| **Weaning time recorded, %**                                   |               |               |                |
| Yes                                                             | 25.0<sup>aA</sup> | 32.7<sup>aA</sup> | 22.7<sup>aA</sup> |
| No                                                              | 75.0<sup>aA</sup> | 67.3<sup>aA</sup> | 77.3<sup>aA</sup> |
| **Causes of extubation failure recorded, %**                    |               |               |                |
| Yes                                                             | 56.9<sup>aA</sup> | 65.4<sup>aA</sup> | 59.1<sup>aA</sup> |
| No                                                              | 43.1<sup>aA</sup> | 34.6<sup>aA</sup> | 40.9<sup>aA</sup> |

NICU: neonatal ICU; PICU: pediatric ICU; NPICU: (mixed) neonatal/pediatric ICU; SBT: spontaneous breathing trial; CPAP: continuous positive airway pressure; PSV: pressure-support ventilation; PEEP: positive end-expiratory pressure; and MV: mechanical ventilation. Proportions followed by the same superscript letters (in lower case for columns and in upper case for rows) did not differ statistically from each other in the multiple comparison tests, p < 0.05 being considered significant.

stability/hemodynamics (in 86%). However, other studies involving pediatric patients have shown that ventilatory parameters prior to extubation and arterial blood gas values were not associated with the success or failure of extubation. Another study involving pediatric patients in Brazil observed that the rapid shallow breathing index and blood gas analyses were not predictors of extubation failure in the postoperative period after cardiac surgery. There are as yet no accurate, reliable criteria to predict success in weaning and extubation in neonatal and pediatric populations. Therefore, subjective rather than evidence-based criteria are employed in most ICUs around the world.

A variety of ventilation modes are used for MV weaning in pediatric patients. A survey carried out in PICUs in Italy found that SIMV+PSV was the ventilation mode most commonly used for weaning, whereas another study reported that the PSV weaning mode was more...
Mechanical ventilation weaning practices in neonatal and pediatric ICUs in Brazil: the Weaning Survey-Brazil

The Weaning Survey-Brazil has some limitations. First, we were unable to obtain contact information for all of the relevant ICUs in Brazil, due to the absence of a single registry containing all such information. In addition, some ICU coordinators did not sign the authorization form. Another limitation is that each questionnaire was completed by only one individual. However, we believe that the questionnaire reliably evaluated the practices in each ICU, because it was completed by the coordinator or intensivist responsible for the unit. In fact, it is possible that the respondents adopted better weaning and extubation practices as they completed the questionnaire. This is a limitation of surveys. Nonetheless, it is noteworthy that this was the first survey to evaluate the profile, in terms of weaning and extubation practices, of NICUs and PICUs in Brazil. In addition, our survey included all of the states and regions of the country. Furthermore, the size of the survey sample (n = 146) was larger than the minimum calculated (n = 82) as being required to be representative of all ICUs in Brazil. The results allow us to understand the practices related to the weaning and extubation processes in the NICUs and PICUs of Brazil, enabling the planning and development of future standardized protocols for the MV weaning in each age group. Optimization of the weaning process could reduce variations in clinical practice, as well as reducing the time on MV, thus reducing the risks associated with ventilation and the costs to the public health system.

In conclusion, the present survey showed that the weaning and extubation practices in Brazil vary widely as a function of the age group served by the ICU. The most common weaning strategy in Brazil is a gradual withdrawal from ventilatory support, and protocolized weaning is more common in PICUs. In PICUs, an SBT is more often performed in the PSV+PEEP ventilation mode, although the duration of the trial was quite variable. In most NICUs and PICUs in Brazil, readiness for extubation is further assessed by clinical and blood gas analysis.

Further studies are needed in order to evaluate the clinical impact of the methods and strategies adopted for MV weaning and extubation of pediatric and neonatology patients in Brazil. Such studies should be

| Table 4. Comparison between ICUs with protocolized ventilator weaning and those without. |
|-----------------------------------------------|---------------|
| Criteria and other variables                  | Use of a weaning protocol |
|                                               | Yes            | No             |
| Weaning and extubation readiness criteria, %   |                |                |
| Clinical criteria                             | 8.3<sup>c</sup> | 6.7<sup>b</sup> |
| Clinical and biochemical criteria             | 59.6<sup>a</sup> | 83.3<sup>a</sup> |
| Clinical criteria, biochemical criteria, and predictive indices, % | 32.1<sup>b</sup> | 10.0<sup>b</sup> |
| Clinical criteria and predictive indices      | ---            | ---            |
| Time frame considered for extubation failure, % |                |                |
| 24 h                                          | 34.5<sup>a</sup> | 14.7<sup>c</sup> |
| 48 h                                          | 42.9<sup>a</sup> | 52.5<sup>a</sup> |
| 72 h                                          | 14.3<sup>b</sup> | 3.3<sup>b</sup>  |
| Undefined                                     | 8.3<sup>b</sup>  | 29.5<sup>b</sup> |
| Frequency of extubation attempts, %           |                |                |
| Patients successfully extubated on the first attempt | 92.9<sup>a</sup> | 87.9<sup>a</sup> |
| Patients required up to 3 extubation attempts | 7.1<sup>b</sup>  | 12.1<sup>b</sup> |
| Use of a weaning protocol after extubation failure on the first attempt, % |                |                |
| Yes                                           | 46.4<sup>a</sup> | 3.3<sup>b</sup>  |
| No                                            | 47.6<sup>b</sup> | 88.5<sup>a</sup> |
| In some cases                                  | 6.0<sup>b</sup>  | 8.2<sup>a</sup>  |
| Time on MV recorded, %                        |                |                |
| Yes                                           | 94.0<sup>a</sup> | 96.7<sup>a</sup> |
| No                                            | 6.0<sup>b</sup>  | 3.3<sup>b</sup>  |
| Weaning time recorded, %                      |                |                |
| Yes                                           | 36.9<sup>a</sup> | 14.8<sup>b</sup> |
| No                                            | 63.1<sup>b</sup> | 85.2<sup>a</sup> |
| Causes of extubation failure recorded, %      |                |                |
| Yes                                           | 71.4<sup>a</sup> | 45.9<sup>a</sup> |
| No                                            | 28.6<sup>b</sup> | 54.1<sup>b</sup> |

MV: mechanical ventilation. Proportions followed by the same superscript lowercase letters in columns did not differ statistically from each other in the multiple comparison tests, p < 0.05 being considered significant.
based on the safety, quality, and productivity indicators applicable in ICUs.

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