ORIGINAL ARTICLE

# Staffing patterns of respiratory therapists in critical care units of Canadian teaching hospitals

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**AJ West, J Nickerson, G Breau, P Mai, C Dolgowicz. Staffing patterns of respiratory therapists in critical care units of Canadian teaching hospitals. Can J Respir Ther 2016;52(3):75-80.**

**BACKGROUND:** The optimal level of respiratory therapy staffing in Canadian intensive care units (ICUs) has not been described in the literature. An examination of practice patterns is an essential first step in developing an understanding of the contribution of respiratory therapists (RTs) to both short- and long-term patient outcomes in this context.

**OBJECTIVE:** To identify the ratio of mechanically ventilated patients to respiratory therapist (Vent:RT ratio) in the ICUs of Canadian teaching hospitals and the factors that influence this ratio.

**METHODS:** The present observational study investigated all adult ICUs (n=38) of the primary teaching hospital associated with each Canadian medical school. An electronic survey was administered at three intervals over a period of three months to control for seasonal variation. Data collected included the hours worked by all RTs, the number of mechanically ventilated patients receiving care, ICU characteristics and the practice patterns of the RTs. Data were used to calculate the Vent:RT ratio, and repeated measures ANOVA examined for variation between findings of each of the data collection points. Correlation analyses between key variables were performed and identified associations were further explored using the *t* test. Approval for the study was granted by the University of Manitoba Research Ethics Board (Winnipeg, Manitoba).

**RESULTS:** A mean (± SD) Vent:RT ratio of 5.1:1±2.818 was determined. Repeated measures ANOVA demonstrated no significant differences between findings of the three data collection points (F [1.7,30.5]=0.695; P=0.492). Several variables were associated with a significant difference in the Vent:RT ratio including ICUs where RTs insert arterial monitoring lines (4.05±2.89 versus 6.97±2.85; t[17.6]=−2.64; P=0.02), neurological ICUs (4.04±2.76 versus 6.40±3.35; t[30]=−2.092; P=0.04) and coronary care units (5.72±2.80 versus 3.10±1.88; t[35]=2.72; P=0.01). Significant differences were also identified in the mean number of RT hours worked in ICUs where RTs intubated (31.40±9.71 versus 60.54±47.20; t(13)=−2.17; P=0.049) and procured arterial blood gases (41.68±30.85 versus 77.33±46.22; t[35]=−2.79; P=0.01).

**CONCLUSIONS:** The present study is the first to report the Vent:RT ratio and RT practice patterns in Canadian adult ICUs. The results serve as a baseline for comparison of staffing norms and will enlighten future research on the impact of RT staffing and practice patterns on patient outcomes.

**Key Words:** *Critical care; Mechanical ventilator; Patient care; Practice patterns; Respiratory therapy*

## La dotation en thérapeutes respiratoires dans les unités de soins intensifs des hôpitaux universitaires canadiens

**HISTORIQUE :** Les publications ne décrivent pas le taux de dotation optimal des thérapeutes respiratoires dans les unités de soins intensifs (USI) canadiennes. À cet effet, il est essentiel de commencer par examiner les profils d'exercice pour comprendre l'apport des thérapeutes respiratoires (TR) aux résultats cliniques des patients à court et à long terme.

**OBJECTIF :** Déterminer le ratio entre les patients sous ventilation mécanique et les TR (ratio Vent:TR) dans les USI des hôpitaux universitaires canadiens et les facteurs qui influent sur ce ratio.

**MÉTHODOLOGIE :** La présente étude d'observation a porté sur toutes les USI pour adultes (n=38) de l'hôpital universitaire de soins de première ligne associé à chaque faculté de médecine canadienne. Les chercheurs ont envoyé un sondage virtuel à trois reprises sur une période de trois mois pour contrôler la variation saisonnière. Ils ont recueilli les heures travaillées par tous les TR, le nombre de patients sous ventilation mécanique traités, les caractéristiques des USI et les profils d'exercice des TR. Ils ont utilisé les données pour calculer le ratio Vent:TR et examiné les mesures de variance répétées pour établir la variation entre les observations à chaque moment de la collecte des données. Ils ont effectué des analyses de corrélation entre les principales variables et examiné de manière plus approfondie les associations établies au moyen du test *t*. Le comité d'éthique de la recherche de l'université du Manitoba, à Winnipeg, a approuvé l'étude.

**RÉSULTATS :** Un ratio Vent:TR moyen (± ÉT) de 5,1:1±2,818 a été établi. Les mesures de variance répétées n'ont démontré aucune différence significative entre les observations à trois moments de la collecte de données (F [1,7, 30,5]=0,695; P=0,492). Plusieurs variables s'associaient à une différence importante du ratio Vent:TR, y compris les USI où les TR insèrent les cathéters intra-artériels (4,05±2,89 par rapport à 6,97±2,85; t[17,6]=−2,64; P=0,02), les USI en neurologie (4,04±2,76 par rapport à 6,40±3,35; t[30]=−2,092; P=0,04) et les unités de soins coronariens (5,72±2,80 par rapport à 3,10±1,88; t[35]=2,72; P=0,01). Les chercheurs ont également constaté des différences significatives en matière de nombre moyen d'heures-TR travaillées dans les USI où les TR procédaient à des intubations (31,40±9,71 par rapport à 60,54±47,20; t(13)=−2,17; P=0,049) et celles où ils effectuaient des gaz artériels (41,68±30,85 par rapport à 77,33±46,22; t[35]=−2,79; P=0,01).

**CONCLUSIONS :** La présente étude est la première à rendre compte du ratio Vent:TR et des profils d'exercice des TR dans les USI pour adultes canadiennes. Les résultats sont un point de départ pour comparer les normes de dotation en personnel et pour éclairer les futures recherches sur les répercussions du nombre de TR et des profils d'exercice sur les résultats cliniques des patients.

Multidisciplinary care teams provide optimal care for mechanically ventilated patients, including registered respiratory therapists (RTs), registered nurses, physicians and health professionals representing several other disciplines. Evidence from clinical epidemiological studies have shown that lower than average staffing levels of health care providers are associated with poor quality of care and increased risk for adverse events in critical care patients and patients on general hospital wards (1-4). While this has been studied extensively to examine nurse to patient ratios and the effects of variable nurse staffing ratios on patient care (3-6), no such figures exist for RTs and, thus, little is known of the effects of variable staffing patterns of RTs on patient outcomes.

Investigations have demonstrated the effectiveness of RT-driven respiratory care in acute care (7-10). One such investigation determined that decreasing costs and increased compliance with established practice guidelines, in the absence of any increase in adverse

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events, was witnessed in RT-driven care when compared with care directed by physicians (11). Similarly, the literature describes the feasibility and effectiveness of implementing non-physician health care professional-driven (typically RT and nurse) weaning strategies for mechanically ventilated patients (12). In Canadian intensive care units (ICUs), RTs are often the primary providers of mechanical ventilation to critically ill patients and, therefore, can be an integral determinant of patient outcomes. While the RT typically undertakes a predominant role in mechanical ventilation management, the literature primarily describes the effectiveness and impact of physician or other health professional's care on ventilated patients' outcomes (1,13). For example, one prospective controlled trial of the impact of mechanical ventilation weaning strategies in ICUs concluded that physician staffing and structured rounds were likely important factors in outcomes as opposed to the type of weaning strategy used (13). Despite the important role of the RT in the ICU, neither the impact of routine RT care nor identification of optimal levels of service in this context has been described in the literature. Because RTs play such a central role in the care of critically ill patients in general, particularly with the provision of mechanical ventilation, further investigation is warranted.

The Canadian Society of Respiratory Therapists (CSRT) has also identified a need for baseline data describing the staffing patterns of RTs in Canada. In the past, it has been articulated by the CSRT membership that such data would be valuable to those who manage health care organizations and respiratory therapy units, and to health care policy and decision makers. As the role of respiratory therapists has continued to expand to include, for example, the insertion of arterial lines, airway management and the management of complex forms of mechanical ventilation, it stands to reason that at some point the ratio of mechanically ventilated patients to RTs (Vent:RT ratio) likely breaches an unsafe threshold, as has been demonstrated for other professions. To achieve this understanding, however, it is essential to understand the current staffing levels and any variation that may exist among institutions. By understanding the current state of RT care, an examination of the effects of variations in staffing patterns and clinical roles can then guide a more robust understanding of the contribution of RTs to both short- and long-term patient outcomes in this environment.

The goal of the present study was to identify the typical Vent:RT ratio in the adult ICUs of Canadian teaching hospitals and the factors that influence this ratio. The results will serve as a platform for identifying potential staffing norms in Canadian ICUs, and will enlighten future research describing the impact of RT staffing and practice patterns on patient outcomes.

## METHODS

The present observational study systematically identified the typical staffing patterns of the ICUs of Canadian teaching hospitals with respect to numbers of RTs relative to the number of mechanically ventilated patients (ie, Vent:RT ratio). The study also sought to determine factors relating to the clinical responsibilities and roles of RTs that may influence this ratio. A survey design was used because it is particularly well suited to identify attributes of large populations from a relatively small group of individuals (14). A survey design was also chosen due to its relative cost effectiveness, timeliness and ease of distribution, enabling multicentre sampling and data collection.

Representatives of ICUs of Canadian teaching hospitals were asked to complete an electronic survey. The survey aimed to identify information relating to the number RTs working in each ICU, the number of mechanically ventilated patients receiving care at the time of the response, and descriptive information regarding the ICU including the scope of professional practice of the RTs employed there. Ethics approval for the study was granted by the Human Health Research Ethics Board of the University of Manitoba (Winnipeg, Manitoba), and informed consent was obtained from each site.

### Sampling

Canada has 17 medical schools accredited by the Association of Faculties of Medicine of Canada (15), all of which are affiliated with at least one major teaching hospital. This was used as a convenient sampling frame because it enables the collection and analysis of data within the context of large Canadian teaching hospitals. Non-teaching hospitals were not evaluated due to the high degree of variability inherent in their contexts and, thus, practice patterns. It was believed that their inclusion would also necessitate a project of significantly larger magnitude than was achievable by the resources available for the present study. This method of sampling provided for a highly representative sample of a clearly definable grouping of institutions whose practices are often used as the benchmarks by other institutions. The selectiveness of the sampling method controlled for over-representation of some geographical locales where there could be a proportionately larger number of sites affiliated with a particular medical school. All participant recruitment was facilitated by the CSRT.

### Inclusion and exclusion criteria

Recruited participants represented the primary teaching hospitals affiliated with one of 17 Canadian medical schools. Satellite or secondary teaching hospitals were not surveyed. If any ambiguity existed, the largest hospital in the nearest geographical region to the university was included. In the case of hospitals with multiple sites within the same city, all sites with relevant data were included if these sites were served by one fully integrated respiratory therapy department. In the case of hospitals with multiple sites, each with independent respiratory therapy departments, only the site with the largest number of ICU beds was chosen. All adult ICUs of recruited teaching hospitals were included regardless of their areas of specialization (eg, cardiac, medical/surgical, etc). Any hospital not affiliated with a Canadian medical school was not included.

### Data collection instrument

A series of three novel questionnaires developed by the researchers were administered to all participants. The number of RTs working and the number of hours worked by each RT, as well as the number of mechanically ventilated patients in each ICU over a specified 24 h period were collected. The survey also collected information relating to the scope of practice of the RTs including typical clinical responsibilities (eg, endotracheal intubation, intrafacility patient transportation, invasive line insertion or monitoring, etc) and the characteristics of the ICU (eg, number of beds, speciality type).

Questions pertaining to staffing levels were based on the number of registered RTs and registry eligible RTs providing direct clinical care within these facilities and units. 'Registry eligible' was defined as graduates of an accredited respiratory therapy education program who have not yet attained licensure by the CSRT, or one of the member organizations of the National Alliance of Respiratory Therapy Regulatory Bodies (16). Data were collected based on the number of patients receiving both invasive and noninvasive mechanical ventilation. Student RTs and staff who do not provide direct patient care (eg, managers) and any ICU not exclusively serving adult patients were excluded from data collection. With respect to questions pertaining to the scope of practice of the RTs, the survey questions were grounded in several key critical care competencies that form part of the National Competency Profile for Canadian RTs (16). No patient-specific information was collected.

### Data collection and analysis

The survey was administered using an online survey platform (Survey Monkey, USA). Data collection occurred at regular monthly intervals over a period of three months (February, March and April, 2015), for a total of three completed surveys representing each ICU included in the study. The data collection periods were specified by the researchers and, thus, the collected survey data represented the same 24 h period for each ICU. This survey approach enabled better comparison

**TABLE 1**
**Baseline sample characteristics (n=38)**

| Professional practice characteristic of RT | |
|---|---|
| Performs endotracheal intubation | 17 (44.7) |
| Insertion of arterial lines | 13 (34.2) |
| Intrafacility patient transport | 35 (92.1) |
| Working in multiple intensive care units | 13 (34.2) |
| Working on general wards | 15 (39.5) |
| Working in emergency room | 10 (26.3) |
| Primarily responsible for ABG procurement | 12 (31.6) |
| Primarily responsible for ABG analysis | 25 (65.8) |
| Ventilator weaning per protocol | 34 (89.5) |
| **Type of critical care unit** | |
| Medical intensive care unit | 24 (63.2) |
| Surgical intensive care unit | 26 (68.4) |
| Cadiovascular intensive care unit | 14 (36.8) |
| Neurlogical intensive care unit | 13 (34.2) |
| Coronary care unit | 10 (26.3) |
| Other intensive care unit type | 6 (15.8) |
| Intensive care unit beds, mean ± SD | 18.21±10.567 |

*Data presented as n (%) of those who responded 'yes' to survey 1, unless otherwise indicated. ABG arterial blood gas; RT Respiratory therapist*

**TABLE 2**
**Mechanical ventilator to respiratory therapist (RT) ratio**

| | Survey | | |
|---|---|---|---|
| | 1 (n=37) | 2 (n=33) | 3 (n=20) |
| Ventilator to RT ratio | 5.01:1±2.818 | 4.78:1±3.108 | 4.51:1±2.931 |
| Ventilators per hour | 10.46±7.654 | 8.79±6.528 | 9.65±7.191 |
| Total number of RT hours worked | 41.30±31.78 | 49.13±35.47 | 47.87±38.37 |
| RTs on 8 h shift | 2.28 | 7.20 | 2.0 |
| RTs on 10 h shift | 0.14 | 0.50 | 0.0 |
| RTs on 12 h shift | 4.50 | 3.87 | 5.44 |
| RTs on other shift | 0.21 | 1.0 | 0.00 |
| ICU beds* | 18.21±10.567 | | |

*Data presented as mean ± SD or mean number of those who responded yes to survey 1. *Collected as baseline data in survey 1 only. ICU intensive care unit*

**TABLE 3**
**Repeated measures ANOVA**

| | Survey | | | Greenhouse-Geisser |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Vent:RT (n=18)* | 4.76±2.976 | 3.92±2.510 | 4.02±2.635 | F=0.695; P=0.492 |
| Ventilation, h (n=23)* | 45.30±31.787 | 49.13±35.470 | 47.87±38.367 | F=0.129; P=0.812 |

*Data presented as mean ± SD unless otherwise indicated. *Analysis necessarily included only intensive care units where data were collected at all three survey intervals. Vent:RT Mechanical ventilator to respiratory therapist (RT) ratio*

of Vent:RT ratios, and provided some limited control for seasonal variability in staffing and patient census that may have had impact on the study findings.

The data were initially analyzed using basic descriptive statistical methods, including key measures of central tendency and measures of dispersion, and graphical analysis of the data to determine its suitability for parametric analyses. The Vent:RT ratio was determined based on the mean number of RTs providing care in each hour compared with the mean number of mechanically ventilated patients in each critical care unit. Such an approach has been used in previous studies to provide nurse-to-patient staffing ratios calculated over a 24 h period using the total number of nurses throughout all shifts in the day, divided by the patient census (17). Data collected in this manner, representing a 24 h period, allows for a common denominator helping to account for the impact of potential variations in staffing patterns that may occur.

Repeated measures ANOVA procedures were performed to examine for variation between the Vent:RT ratio identified at each of the three sampling intervals. The analysis then sought to identify factors that may influence the Vent:RT ratio. Correlation analyses between the professional practice characteristics of the RTs and the mean Vent:RT, and between the ICU characteristics and the mean Vent:RT were performed using Pearson's r. The existence of correlations supported further explorations of these relationships usung the paired samples *t* test. Differences were considered to be statistically significant at $P<0.05$. All statistical analysis were performed using SPSS version 18.0 (IBM Corporation, USA).

## RESULTS

The response rate to the survey recruitment initiatives was very good, with 16 of 17 (94%) academic health science centres associated with medical schools participating. A total of 38 teaching hospital ICUs were included in the study, representing the 17 academic health science centres. Individual response rates were higher for the first survey (n=37 [97%]) and dropped somewhat in the second (n=33 [87%]) and third (n=20 [53%]) surveys. The waning response rate over the three survey intervals likely reflected surveyor fatigue. All attempted surveys were fully completed and, thus, none were discarded for incomplete information.

Descriptive analysis of the professional practice characteristics of the RTs working the surveyed ICUs and the characteristics of the ICUs were performed (Table 1). Further exploration of each variable through graphical analysis allowed visual confirmation that the data were normally distributed and, thus, that further parametric analysis was appropriate.

The data were then analyzed to calculate the Vent:RT ratio from data collected at each of the three survey intervals (Table 2). A mean (± SD) Vent:RT of 5.1:1±2.818 was identified from data collected in the first survey, 4.78:1±3.108 from the second survey and 4.51:1±2.931 from the third survey. Repeated measures ANOVA procedures were used to examine whether variation between key findings in each of the three surveys existed (Table 3). Analysis using ANOVA necessarily included only ICUs in which data were collected at all three survey intervals and, therefore, no drop-outs were included in this portion of the analysis. ANOVA demonstrated no significant differences between findings of the three data collection points ($F[1.7,30.5]=0.695$; $P=0.492$), thus supporting the value in exploring and reporting relationships that may exist between variables in the data collected at any of the three survey intervals.

Correlation analyses between RT professional practice patterns and the mean Vent:RT, and between ICU characteristics and the mean Vent:RT was performed. Several important correlations were identified and are presented in Table 4. Paired-samples *t* test provided further evidence of the relationships between variables in which correlations had been identified. Several variables were associated with a significant difference in the Vent:RT ratio including ICUs where RTs insert arterial monitoring lines (4.05±2.89 versus 6.97±2.85; $t[17.6]=-2.64$; $P=0.02$), neurological ICUs (4.04±2.76 versus 6.40±3.35; $t[30]=-2.092$; $P=0.04$) and coronary care units (5.72±2.80 versus 3.10±1.88; $t[35]=2.72$; $P=0.01$). Significant differences were also identified in the mean number of RT hours worked over a 24 h period in ICUs where RTs intubated (31.40±9.71 versus 60.54±47.20; $t[13]=-2.17$; $P=0.049$) and procured arterial blood gases (41.68±30.85 versus 77.33±46.22; $t[35]=-2.79$; $P=0.01$). Mean comparatives are presented for ICUs where the variable was present versus those where

**TABLE 4**
**Correlations between key variables**

| RT practices and intensive care unit characteristics | Survey 1 (n=37) 8 h shifts | 10 h shifts | 12 h shifts | RT worked hours | Vent:RT | Survey 2 (n=33) RT worked hours | Vent:RT | Survey 3 (n=20) RT worked hours | Vent:RT |
|---|---|---|---|---|---|---|---|---|---|
| Performs ETT intubation | **0.353** | 0.250 | **0.535** | 0.256 | 0.224 | 0.081 | 0.257 | 0.385 | 0.099 |
| Insertion of arterial lines | **0.390** | **0.349** | **0.651** | 0.402 | −0.019 | −0.228 | 0.413* | −0.066 | **0.449** |
| Intrafacility patient transport | 0.084 | 0.104 | 0.121 | 0.131 | −0.064 | 0.041 | 0.082 | 0.184 | −0.209 |
| Working in multiple intensive care units | 0.060 | 0.045 | 0.136 | 0.026 | −0.070 | **0.498** | -0.343 | **0.601** | −0.228 |
| Working on general wards | −0.055 | −0.137 | 0.098 | 0.052 | −0.311 | −0.193 | -0.233 | −0.048 | 0.014 |
| Working in emergency room | 0.173 | −0.033 | 0.061 | 0.086 | 0.039 | **0.465** | -0.323 | **0.655** | −0.307 |
| Responsible for ABG procurement | **0.424** | 0.278 | 0.372 | **0.427** | −0.006 | 0.164 | 0.191 | −0.153 | 0.233 |
| Responsible for ABG analysis | 0.122 | 0.099 | 0.157 | 0.238 | −0.006 | −0.184 | -0.006 | −0.169 | **0.487** |
| Ventilator weaning per protocol | **0.356** | 0.306 | 0.306 | 0.296 | 0.221 | 0.178 | 0.220 | 0.136 | 0.362 |
| Medical intensive care unit | 0.321 | 0.161 | 0.201 | 0.196 | 0.174 | −0.033 | 0.178 | −0.126 | 0.212 |
| Surgical intensive care unit | 0.272 | 0.163 | 0.219 | 0.143 | 0.166 | −0.072 | 0.258 | −0.174 | 0.328 |
| Cadiovascular intensive care unit | 0.225 | 0.273 | 0.412 | 0.133 | 0.260 | −0.007 | 0.269 | 0.226 | 0.083 |
| Neurlogical intensive care unit | **0.360** | **0.360** | 0.123 | 0.292 | 0.095 | 0.025 | **0.357** | −0.263 | 0.155 |
| Coronary care unit | −0.303 | −0.168 | 0.068 | -0.138 | **0.418** | 0.027 | -0.226 | 0.179 | −0.093 |
| Other intensive care unit type | −0.036 | −0.168 | −0.045 | -0.051 | −0.125 | −0.041 | -0.242 | −0.105 | 0.042 |
| Intensive care unit beds, n | **0.812** | **0.626** | **0.803** | **0.791** | 0.053 | 0.140 | 0.261 | 0.149 | **0.515** |

**Bolded values indicate Pearson's correlation coefficient found to be statistically significant (P<0.05 [two tailed]). ABG arterial blood gas; ETT Endotracheal tube; RT Respiratory therapist; Vent:RT Mechanical ventilator to RT ratio*

it was not. Several of these variables demonstrated significant mean differences when compared across multiple survey intervals (Table 5). For example, the insertion of arterial lines demonstrated significant between-group differences in the Vent:RT ratio in both survey 2 and 3.

## DISCUSSION

### The Vent:RT ratio

Data were collected at three separate intervals and each measure of the Vent:RT ratio was made using the same sample set. Because no significant differences between the findings of each of the three interval points were identified ($F[1.7,30.5]=0.695$; $P=0.492$), each measure was, therefore, considered to be representative of the relationship of the Vent:RT ratio. Data from the first survey were, however, characterized by the largest response rate (n=38) (compared with n=33 in survey 2 and n=20 in survey 3) as well as the lowest SD (2.818 compared with 3.108 in survey 2, and 2.931 in survey 3) from among the survey intervals. It was, therefore, determined that from among the three survey intervals that the data collected in the first survey provided the best representation of the Vent:RT ratio. The present study identified that the mean Vent:RT ratio among the ICUs of Canadian teaching hospitals is estimated to be 5.1:1.

The approach to collecting data over separate intervals was intended to account for some degree of seasonal variability and may have, therefore, helped mitigate the impact of phenomenon that could have periodically influenced RT staffing levels in ICUs. It has been well documented that seasonal health patterns, such as influenza, can lead to illness burden, which necessitate critical care intervention including intensive respiratory therapy (18). Shilling et al (19) demonstrated that a variety of factors, such as seasonal influenza, hospital occupancy, weekend admission and nurse staffing levels, each are independently associated with in-hospital mortality. Recognizing these associations, it may, therefore, be important for hospital administrators to consider factors such as seasonally related burden of illness and patient flow when applying these findings.

### Factors that impact the practice patterns of RTs

A variety of the professional practice-related variables included in the analysis were associated with the Vent:RT ratio. Of the variables analyzed, each can be broadly categorized as either relating to the ICU setting or to the professional scope of practice of the RTs practicing in the ICU environment.

With respect to the ICU setting, it was determined that neurological ICU settings were associated with lower Vent:RT ratios, while coronary care units were associated with an increased ratio. The Vent:RT ratio was not significantly associated with other identified ICU specialty types (medical, surgical, cardiovascular). These findings suggest what many experienced practitioners anecdotally report: that the practice patterns of respiratory therapists are somewhat consistent across ICU settings. However, the strength of the associations between the ratio and a neurological ICU or coronary care unit setting may relate to mechanically ventilated patients tending to exhibit respiratory therapy needs existing at either end of a spectrum of complexity (eg, variations in need for critical intrafacility transportation or for advanced modes of mechanical ventilator).

Additional staffing factors believed to likely contribute to increased workload for RTs were found to be significantly associated with the number of hours worked by RTs. These included ICUs in which RTs' worked in other ICUs at the same time, or where RTs were working in an emergency room at the same time. These findings suggest a negative impact on the number of RT working hours in ICUs reporting that RTs also work in other critical care units. In such cases, working in additional critical care units showed a trend toward increased Vent:RT ratios, although these did not reach significant levels. Not surprisingly, the number of ICU beds was also determined to directly correlate with the number of RTs working in the ICUs.

Acuity of care has been a factor that, alongside nurse staffing levels, has been identified in the nursing literature as associated with patient outcomes (20). While the present study did not directly seek correlations between acuity of care and RT staffing levels, the variation between practice settings (as determined by ICU type) suggests that acuity of patient care may be a confounding variable. Based on this understanding, the utilization of RT staffing benchmarks that incorporate measures of patient acuity are suggested.

Several factors relating to the professional scope of practice of Canadian RTs that were anticipated to potentially impact their staffing patterns were also included in the analysis. Of those factors, a variety were found to be significantly associated with either the Vent:RT ratio or to the number of hours worked by RTs in the ICUs surveyed. These factors included RTs who performed intubation, inserted arterial lines, procured or analyzed arterial blood gases or managed ventilators according to a weaning protocol. It was not surprising to the research team that these critical procedural skills were

**TABLE 5**
**t test for equality of means**

| RT practices and ICU characteristics | Survey 1(n=37) | | Survey 2 (n=33) | | Survey 3 (n=20) | |
|---|---|---|---|---|---|---|
| | RT worked hours | Vent:RT | RT worked hours | Vent:RT | RT worked hours | Vent:RT |
| Performs ETT intubation | 44.0±38.15; 64.12±39.75 | 4.44±2.73; 5.69±2.85 | 42.48±32.73; 48.63±44.70 | 4.17±2.632; 5.79±3.669 | **31.40±9.71; 60.54±47.20*** | 4.23±3.31; 4.79±2.65 |
| Insertion of arterial lines | 41.67±35.35; 74.62±39.53 | 5.05±3.36; 4.94±1.49 | 51.04±39.77; 32.83±31.75 | **4.05±2.89; 6.97±2.85*** | 49.86±43.91; 44.78±29.97 | **3.57±3.149; 6.29±1.377*** |
| Working in multiple ICUs | 52.50±43.44; 54.62±33.18 | 5.16±2.61; 4.75±3.27 | **32.24±33.43; 72.00±33.16** | 5.59±3.25; 3.43±2.42 | **28.08±22.75; 73.6±40.09*** | 5.16±2.95; 3.86±2.91 |
| Working in emergency room | 51.19±40.90; 58.80±37.62 | 4.95±2.66; 5.19±3.37 | **35.29±33.25; 75.78±36.6*** | 5.40±3.23; 3.20±2.22 | **29.93±22.67; 81.5±40.20*** | 5.23±2.91; 3.44±2.80 |
| Responsible for ABG procurement | **41.68±30.85; 77.33±46.2*** | 5.03±3.23; 4.99±1.79 | 41.15±35.02; 54.55±44.37 | 4.39±2.65; 5.65±3.96 | 52.07±41.94; 40.00±31.62 | 4.08±2.97; 5.53±2.81 |
| Responsible for ABG analysis | 40.62±29.61; 60.08±43.20 | 5.25±3.93; 4.89±2.09 | 54.46±39.68; 40.08±36.77 | 4.80±4.36; 4.76±2.00 | 55.78±58.31; 42.79±18.10 | **2.39±2.45; 5.42±2.70*** |
| Neurological ICU | 44.83±32.93; 68.77±47.33 | 4.82±3.39; 5.37±1.28 | 44.48±34.73; 46.50±45.49 | **4.04±2.76; 6.40±3.35*** | 55.07±41.47; 34.38±29.45 | 4.22±3.08; 5.19±2.67 |
| Coronary care unit | 56.52±43.48; 44.40±26.71 | **5.72±2.80; 3.10±1.88*** | 44.57±38.63; 46.89±37.78 | 5.18±3.11; 3.58±2.98 | 43.44±39.38; 58.00±36.72 | 4.71±2.83; 4.15±3.32 |

*t test for equality of means for all variables found to have statistically significant correlations (bolded values) with ventilator to respiratory therapist (RT) ratio (Vent:RT); or measures of RT works hours (mean ± SD of those who responded 'yes'; mean ± SD of those who responded 'no'). 'Ventilator weaning per protocol' not included in analysis due to insufficient sample size for testing. *Indicates significant difference (P<0.05 [two-tailed]). ABG arterial blood gas; ETT Endotracheal tube; ICU intensive care unit*

related to RT staffing given the impact each would have on the time demands of practicing RTs.

Part of the rationale for focusing the present study design on one hospital type (ie, teaching hospitals) was due to presumed practice differences between teaching hospitals and nonteaching hospitals. Based on the experiences of the research team in both teaching and nonteaching hospital contexts, it was expected that differences in the proportion of RTs performing many critical skills would exist between these settings. This was hypothesized to relate to an increased access to a broader range of advanced practitioners at teaching hospitals (eg, senior residents or nurse practitioners), and the need for trainees of those professions to access skill development opportunities; thus, potentially limiting RT involvement in some practices. While recognizing this, the proportion of teaching hospital ICUs where RTs routinely engaged in the critical care skills surveyed were lower than anticipated. For example, RTs routinely perform intubation at 45% of the ICUs surveyed, routinely insert arterial lines at 34% and routinely procure arterial blood gases at 32%.

The low proportion of ICUs where critical competencies were performed may, in part, be an indication that the survey used did not capture the full breadth of relevant ICU RT practice-related factors. For example, RT participation in bronchoscopy procedures was not surveyed, although may be more commonplace in teaching hospital ICUs than in other centres. Furthermore, our reliance on sentinel indicators of the complexity of RT practice (eg, performing intubations) may not accurately reflect the true complexity of the care provided by RTs. For example, performing complex mechanical ventilation or the degree of autonomy given to RTs to make important therapeutic decisions is not adequately captured by procedural metrics such as intubations performed or arterial blood gases procured. However, the scope of practice described in the National Competency Profile (NCP) for Canadian RTs encompass the comprehensive set of skills required for entry to practice in the profession (16). Moreover, the skills described in the NCP represent those practiced by the majority of RTs in Canada, as have been determined through a national validation process (16). Given that each skill included in the survey tool was grounded in the most recent version of the NCP, it remains surprising that a sample of ICUs representing the practices of a substantial segment of RT practice in Canada showed remarkably low rates of performing these skills.

These findings are an indication of the breath of practice scope that exists in the RT profession in Canada, and suggest the need to exercise caution when generalizing the findings presented in the NCP to particular practice environments. Based on these findings, deeper exploration in the teaching hospital context is encouraged, and comparative inquiry into the range of practices in nonteaching hospital settings is warranted, including any potential variations that may be impacted by other factors such as rurality. Our understanding of these potentially confounding factors will be important for informing future outcomes-oriented research.

**Limitations**

Because of the preliminary nature of the present study, it was not feasible to examine the contribution of these patterns to patient outcomes. While we recognize the central importance of outcomes health research, the present observational study was believed to be a necessary step in establishing data that will, in turn, support outcome-oriented research. This approach was believed useful in providing valuable data that will serve as a method of benchmarking among comparable organizations.

The sampling framework of the present study has implications for its generalizability to Canadian ICUs. Limiting participant ICUs to those in teaching hospitals associated with medical schools provided a researchable contextual frame, which is commonly used for controlled inquiry within the health care system. Doing so, however, also potentially limited the applicability of these findings because differences in staffing and patient characteristics among smaller community hospitals or nonteaching hospitals in major cities are likely to differ from those encountered in the academic teaching hospitals. Moreover, the sampling framework impacts the ability of these findings to be directly generalized to practice contexts, such as critical care units in small and rural communities, in specialized institutions such as children's hospitals, or for specialty areas not included such as pediatric and neonatal ICUs outside of children's hospitals.

The method used for determining the Vent:RT ratio from the collected data was chosen because it was an achievable and robust approach to examining the practice pattern. The mean Vent:RT ratio was determined based on the mean calculation of the hourly RT hours worked in each ICU, which was derived from the total RT hours worked over a 24 h period. It is worth noting, therefore, that any wide variations in staffing (eg, an ICU that had four RTs working during the day and two RTs working at night) would not have been evident through this analysis. Therefore, when interpreting the results of the present study, the possibility that fluctuations in the ratio may be expected at different points over a 24 h period should be noted.

## CONCLUSION

The findings of the present study provide what we believe to be the first reported assessment of RT staffing patterns in Canadian teaching hospital ICUs. Our assessment determined a typical ratio of 5.1 mechanical ventilators to each RT (ie, Vent:RT= 5.1) working in the ICUs of Canadian teaching hospitals. A variety of factors related to both the typical practices of the RTs and the care specialization of the ICU were associated with changes in the Vent:RT ratio. Specifically, decreases in the ratio were associated with ICUs where RTs intubated, procured arterial blood gases, inserted arterial lines and in neurological ICUs. Conversely, coronary care units were associated with an increased Vent:RT ratio.

These results will serve as a platform for identifying potential staffing norms in Canadian ICUs and will inform future research describing the impact of RT staffing and practice patterns on patient outcomes. We believe this is an area of emerging research importance in an evermore outcomes-oriented health care system, and further research is needed to understand the impact and implications of varying Vent:RT ratios on important patient and health systems outcomes. For example, similar to investigations in other disciplines, the impact of variable RT staffing ratios on the length of stay and mortality of mechanical ventilated patients would be useful. Access to the findings of patient outcomes-oriented research in respiratory therapy will be particularly important for health care planners and policy makers.

**ACKNOWLEDGMENTS:** The authors gratefully acknowledge the financial and administrative support for this research provided by the Canadian Society of Respiratory Therapists.

**DISCLOSURES:** The authors have no financial disclosures or conflicts of interest to declare.

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