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REPORTS OF ORIGINAL INVESTIGATIONS

Critical care services in Ontario: a survey-based assessment of current and future resource needs

Services en soins critiques en Ontario: une évaluation basée sur un questionnaire concernant les besoins en ressources actuels et futurs

Andrea D. Hill, MSc · Eddy Fan, MD · Thomas E. Stewart, MD · William J. Sibbald, MD · Eric Nauenberg, PhD · Bernard Lawless, MD · Jocelyn Bennett, RN · Claudio M. Martin, MD

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Abstract

Purpose *In response to the challenges of an aging population and decreasing workforce, the provision of critical care services has been a target for quality and efficiency improvement efforts. Reliable data on available critical care resources is a necessary first step in informing these efforts. We sought to describe the availability of critical care resources, forecast the future requirement for the highest-level critical care beds and to determine the physician management models in critical care units in Ontario, Canada.*

Methods *In June 2006, self-administered questionnaires were mailed to the Chief Executive Officers of all acute care hospitals, identified through the Ontario government's hospital database. The questionnaire solicited information on the number and type of critical care units, number of beds, technological resources and management of each unit.*

Results *Responses were obtained from 174 (100%) hospitals, with 126 (73%) reporting one or more critical care units. We identified 213 critical care units in the province, representing 1789 critical care beds. Over half (59%) of these beds provided mechanical ventilation on a regular basis, representing a capacity of 14.9 critical care and 8.7 mechanically ventilated beds per 100,000 population. Sixty-three percent of units with capacity for mechanical ventilation involved an intensivist in admission and coordination of care. Based on current utilization, the demand for mechanically ventilated beds by 2026 is forecast to increase by 57% over levels available in 2006. Assuming 80% bed utilization, it is estimated that an additional 810 ventilated beds will be needed by 2026.*

Conclusion *Current utilization suggests a substantial increase in the need for the highest-level critical care beds over the next two decades. Our findings also indicate that non-intensivists direct care decisions in a large number of*

Dr. Sibbald is deceased.

A. D. Hill, MSc (✉) · T. E. Stewart, MD
University Health Network, Toronto General Hospital, 200 Elizabeth Street, 11C-1165, Toronto, ON, Canada M5G 2C4
e-mail: andrea.hill@uhn.on.ca

E. Fan, MD · T. E. Stewart, MD · W. J. Sibbald, MD
Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, ON, Canada

E. Fan, MD
Division of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, MD, USA

T. E. Stewart, MD · J. Bennett, RN
Mount Sinai Hospital, Toronto, ON, Canada

W. J. Sibbald, MD
Sunnybrook Health Sciences Centre, Toronto, ON, Canada

E. Nauenberg, PhD
Department of Health Policy Management and Evaluation, University of Toronto, Toronto, ON, Canada

B. Lawless, MD
Department of Surgery, University of Toronto, Toronto, ON, Canada

C. M. Martin, MD
Centre for Critical Illness Research, Lawson Health Research Institute, London Health Sciences Centre and the University of Western Ontario, London, ON, Canada

responding units. Unless major investments are made, significant improvements in efficiency will be required to maintain future access to these services.

Résumé

Objectif *En réponse aux défis posés par le vieillissement de la population et une diminution de la population active, la prestation de services de soins critiques est devenue un objectif prioritaire des efforts d'amélioration de la qualité et de l'efficacité. Des données fiables concernant les ressources en soins critiques constituent une première étape nécessaire afin de documenter ces efforts. Notre objectif était de décrire la disponibilité des ressources en soins critiques, prédire le besoin futur en matière de lits pour les soins critiques de plus haut niveau, et de déterminer les modèles de prise en charge par les médecins dans les unités de soins critiques en Ontario, Canada.*

Méthode *En juin 2006, des questionnaires auto-administrés ont été envoyées aux chefs de la direction de tous les hôpitaux de soins aigus; leurs noms avaient été tirés de la base de données des hôpitaux du gouvernement de l'Ontario. Le questionnaire demandait des informations sur le nombre et le type d'unités de soins critiques, le nombre de lits, les ressources technologiques et la prise en charge dans chaque unité.*

Résultats *Des réponses ont été obtenues de 174 (100 %) hôpitaux, et 126 (73 %) déclaraient disposer d'une ou plusieurs unité(s) de soins critiques. Nous avons identifié 213 unités de soins critiques dans la province, ce qui représente un total de 1789 lits de soins critiques. Plus de la moitié (59 %) de ces lits fournissent une ventilation mécanique de façon régulière, ce qui représente une capacité de 14,9 lits en soins critiques et 8,7 lits avec ventilation mécanique par population de 100 000 personnes. Dans 63 % des unités disposant de ventilation mécanique, un intensiviste était impliqué dans le processus d'admission et de coordination des soins. Sur la base de l'utilisation actuelle de ces lits, on prédit que la demande pour des lits avec ventilation mécanique devrait augmenter de 57 % d'ici 2026 par rapport aux niveaux de 2006. Si l'on suppose une occupation des lits à 80 %, on estime que 810 lits supplémentaires avec ventilation mécanique seront nécessaires d'ici 2026.*

Conclusion *L'utilisation actuelle suggère qu'une augmentation considérable de lits de soins critiques de plus haut niveau sera nécessaire dans les 20 prochaines années. Nos résultats indiquent également que des médecins non-intensivistes sont en charge des décisions de soins dans un nombre élevé d'unités ayant répondu au questionnaire. À moins que des investissements importants soient faits, des améliorations considérables au niveau de l'efficacité seront nécessaires si l'on veut maintenir l'accès à ces services à l'avenir.*

Introduction

Provision of critical care services represents a resource intensive specialty within a hospital.[1,2] In North America, critical care services are estimated to account for 8–20% of all inpatient costs, representing between 0.2 and 0.8% of the gross national product (GNP) of Canada and the United States, respectively.[2] Given advances in technology and therapeutics and an aging population, current evidence suggests that the demand for critical care services will increase.[3,4] It is expected that the severe shortages in critical care human resources will result in further challenges to the current health care system.[3]

The 2003 outbreak of severe acute respiratory syndrome (SARS) in Ontario, Canada resulted in tremendous pressures on the critical care system.[5,6] The unexpected influx of approximately 80 SARS patients, coupled with closures of several hospitals due to quarantine, highlighted not only a shortage of critical care capacity but also a system that was functioning at or above capacity with little or no ability to respond appropriately to unexpected surges in demand.[7] Similar inadequacies in the supply of critical care resources have been reported in other jurisdictions.[8,9]

Addressing the challenges presented by shortages in capacity and by expected increases in the demand for critical care services requires accurate data to inform policy decisions. This study outlines the process used by one health region to: (1) determine the availability of adult critical care resources; (2) predict the future requirement for the highest-level critical care beds (i.e., those capable of providing mechanical ventilation) based on current resources; and (3) determine the extent of physician management models in critical care units across the region. This exercise is relevant to all regions, both national and international, that provide critical care services to an aging population.

Methods

Questionnaire development

The initial questionnaire was developed based on a review of the literature and an examination of existing measures. Modifications to reflect current priorities were made by members of Ontario's Critical Care Local Health Integration Network (LHIN) Leader Table, a group of 14 intensivists responsible for providing operational leadership to improve the delivery of critical care services across the province. To ensure both face and content validity, the questionnaire was circulated for review by a panel of stakeholders that included the full membership of the Critical Care LHIN Leader Table, nurses, intensivists, and

other representatives from the Ministry of Health and Long-Term Care (MOHLTC). Based on the panel's feedback, items were added, modified, or deleted to improve comprehensiveness and clarity.

The resulting 30-item questionnaire included questions regarding the number of critical care units, the total number of acute care and critical care beds, technological and medical resources, and the administrative structure of critical care units. A liberal definition of critical care was used to include beds in traditional intensive care units (ICUs), intermediate care units, burn units, and coronary/cardiac care units. Telemetry capable beds on a general unit were excluded. Mechanically ventilated beds were defined as beds capable of supporting invasively mechanically ventilated patients. For patient management questions, an intensivist was defined as a physician with Royal College of Physicians and Surgeons of Canada accreditation or equivalent training in critical care medicine, or specialists with a minimum of six post-graduate months of critical care training. Table 1 provides the distinction between Level 2 and Level 3 units.

Sample and survey implementation

The geographic area selected for this study included all hospitals in the province of Ontario. This represents a spectrum of acute care hospitals ranging from smaller community hospitals to larger urban teaching centres and includes a mix of critical care units.

In June 2006, the questionnaire and a letter detailing the purpose of the survey were mailed to the Chief Executive Officers of all acute care hospitals identified through the Ontario government's hospital database. Since all acute care hospitals are funded through the government of Ontario, the list represented a complete inventory of hospitals. Respondents were given approximately 4 weeks to complete one questionnaire for each critical care unit at their institution. Follow-up calls and electronic messages were sent to non-respondents during August 2006. Additional calls were made to clarify incomplete and inconsistent data. Data collection ended in September 2006.

Statistical analysis

Given the very broad definition used to define a critical care bed, we focused on the highest-level and most costly beds in the forecasting models by including only those beds capable of mechanical ventilation. The data for predicting the future requirement for mechanically ventilated beds were derived from the critical care capacity survey and from two other sources. First, from Ontario's Ministry of Finance (MOF) database, we extracted age-group specific population data for 2004 (2006 data was not available) and population projections until 2031. The second database we used was the Critical Care Research Network (CCR-Net) minimum dataset (MDS), which represents a registry of admissions to the ICUs of hospitals participating in the CCR-Net collaborative.[10] Information from all 18 critical care units reporting to the MDS during the period from January 1 to December 31, 2006 were abstracted from this database in order to estimate the age of the typical adult patients in mechanically ventilated beds in Ontario. These units accounted for 223 (21%) of the total number of mechanically ventilated beds reported in the current survey. A description of the 18 CCR-Net units is provided in Table 2. Compared to the other hospitals included in this survey, the included units were typically larger with a higher proportion of mechanically ventilated beds. However, for forecasting purposes, we assumed that the age spectrum of adult patients in these mechanically ventilated beds was adequately representative of patients in the whole group of hospitals. Patients in the sample were categorized into eight age groups as follows: ages less than 30 (15–29), 30–39, 40–49, 50–59, 60–69, 70–79, 80–89, and 90 years or older. To estimate the total number of critically ill

Table 1 Definitions applied to critical care units

Level 2	Level 3
Capable of providing service to meet the needs of patients who require more detailed observation or intervention, including support for a single failed organ system, short-term non-invasive ventilation, and post-operative care, as well as support for patients "stepping down" from higher levels of care or "stepping up" from lower levels of care. These units provide a level of care that falls between the general ward (Level 1) and a "full service" critical care unit (Level 3).	Capable of providing the highest level of service to meet the needs of patients who require advanced or prolonged respiratory support, or patients who require basic respiratory support together with the support of more than one organ system. These units are generally considered "full service" critical care units, despite the fact that some specialized services may not be available (e.g., dialysis).
Level 2 units do not provide invasive ventilatory support.	All Level 3 units are capable of invasive ventilatory support.

Note: Critical care units that provide invasive mechanical ventilation for the short-term (e.g., ≤48 h), but must transfer patients requiring additional long-term invasive ventilation to a Level 3 unit, are considered Level 2 for the purposes of the service inventory

Table 2 Description of the CCR-Net critical care units

Characteristics	
Age (mean, SD)	62.5 (17)
APACHE II (mean, SD)	17.9 (9)
LOS (median, IQR)	2.25 (13.7)
Closed (*N*, %)	8 (44)

CCR Critical Care Research Network, *APACHE* Acute Physiology and Chronic Health Evaluation, *LOS* length of stay

patients who were mechanically ventilated in acute care hospitals in Ontario in 2006, we inflated the number of patients in each age category by a factor of 4.7 (100/21). This figure was then applied to MOF population data for 2004 to estimate the percent of the total Ontario population in 2006 that required mechanical ventilation in each age stratum. The estimated proportion of the population requiring mechanical ventilation in each age stratum was applied to the MOF population forecast for the years 2011 and 2026, in order to determine the projected number of patients who will require mechanical ventilation for these points in time. The following strategy was used for the analyses. First, we calculated the total number of mechanically ventilated bed-days available in 2006 (i.e., the total number of mechanically ventilated beds reported in the survey multiplied by 365 days). Second, we calculated the total number of filled bed-days as the total number of bed-days available in 2006 multiplied by current occupancy (assumed 90%). The assumption of 90% occupancy was made based on expert opinion of the current bed average occupancy rate in Ontario. Third, the number of ventilated days per case in 2006 was calculated as the total number of filled bed-days in 2006 divided by the estimated province-wide number of hospitalized cases requiring mechanical ventilation in 2006. Finally, to obtain the total number of annual patient days in critical care units (filled bed-days), the average number of mechanically ventilated bed-days in 2006 was multiplied by the estimated number of annual critical care patients at each five-year interval between 2011 and 2026. To determine the number of mechanically ventilated beds that will be required at these time points, this result was divided by 365 and adjusted for a 90% occupancy rate. The assumptions supporting this methodology are detailed in Table 3.

We performed several sensitivity analyses to examine the strength of our estimates, including testing the effects of a varying current occupancy rate (90% versus 80%) and different population projections (i.e., the MOF reference and high and low population estimates for 2011 and 2026).

We report frequencies, means, cross-tabulations, and other descriptive measures to describe the current critical care resources and future projections for mechanically ventilated beds across Ontario.

Table 3 Assumptions for forecasting mechanical ventilation bed requirements

Assumptions
1. The selected sample of ICUs from the CCR-Net dataset is representative of adult admissions to critical care units across the province
2. The 2004 capacity is adequate to meet current demand; therefore, the forecasts are established on the presupposition that the province will maintain a capacity approximating 2004 until the year 2026
3. 90% occupancy is the current occupancy rate for mechanically ventilated beds
4. It is assumed that the average annual bed-days per mechanically ventilated patient, as maintained in 2004, will remain constant throughout time

ICU intensive care unit, *CCR* Critical Care Research Network

Results

Bed capacity

Responses were obtained from all 129 hospital corporations that were contacted (174 individual acute care hospitals). Reports from 48 individual hospitals (27%) indicated no capacity for adult critical care services, while the remaining hospital reports included details on 213 critical care units. The total number of adult critical care beds in these units was 1789 (range, 1–30). Of these, 1627 (91%) were located in 76 hospital corporations with Level 3 critical care units (a total of 99 Level 3 units). The remaining beds were located in 50 hospital corporations with a maximum of Level 2 critical care capacity. Mechanically ventilated beds accounted for 1057 (59%) of the total number of critical care beds. The bed capacities represent 14.9 critical care and 8.7 mechanically ventilated beds per population of 100,000.

Thirty-eight percent of 213 units were reported as mixed ICU/coronary care units (CCU), while 17% were identified as general ICUs. Almost 13% of these units were CCU. When considering only those units capable of providing mechanical ventilation, 26.5 and 45% were general ICUs and mixed ICU/CCU, respectively. Units not capable of providing mechanical ventilation were predominantly step-down/step-up units.

Coordination of care

Sixty-three percent of the Level 3 units involved an intensivist in all patient admission, discharge, and care decisions (Table 4). This number increased to 74% when only Level 3 units with eight or more beds were considered. Units not providing mechanical ventilation (Level 2) utilized intensivists to a lesser degree (data not shown).

Table 4 Intensivist management of critical care units

	Unit size		
Decision maker (*n*, %)	<8 beds	8–12 beds	≥13 beds
Intensivist led	6 (27)	22 (59)	35 (88)
Non-Invensivisit led	16 (73)	15 (41)	5 (12)
Total	22	37	40

Forecasting needs for mechanically ventilated beds

Assuming a utilization rate of 90%, it is projected that an additional 130 mechanically ventilated beds will be required by 2011. The number of new beds is expected to increase to 602 by 2026 (Fig. 1a). Under ideal utilization rates (80% occupancy), the predicted need for mechanically ventilated beds increases markedly from a total of 1057 beds in 2006 to 1337 by 2011, an increase of 26%. By 2026, this number would almost double to 1869 new mechanically ventilated beds (Fig. 1b). Figure 1 summarizes the sensitivity analyses derived by varying the population estimates for current (90%) and ideal (80%) occupancy rates, respectively.

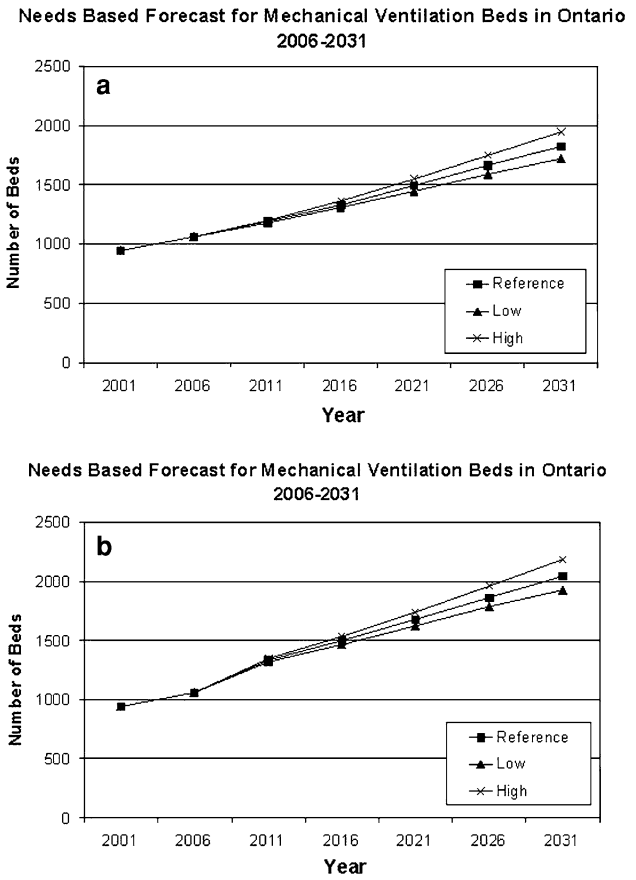

Fig. 1 Needs-based forecast for mechanically ventilated beds in Ontario under **a** 90% and **b** 80% service utilization for reference (■), low (▲) and high (×) population projections

Discussion

The 100% response rate obtained in this study is higher than earlier audits completed in the United States,[11,12] but similar to more recent reports.[13] International comparisons of per capita critical care bed numbers demonstrate marked variation in the availability of critical care services.[14] Consistent with this evidence, our data show that Ontario has just over half the number of critical care beds per capita compared to the United States,[11] but almost twice the number reported by the United Kingdom.[14] Clearly, given the costs associated with providing critical care services, there is an inconsistent expenditure across jurisdictions. Without information on clinical outcomes and the economic and cultural settings in which care is delivered, the comparison of data across countries regarding the number of critical care beds per capita provides limited insight into the adequacy of the provision of critical care services. Notwithstanding, our findings will be valuable for decisions in the province regarding the need for future critical care bed resources and their most effective allocation.

Two key findings with significant implications for the delivery of critical care services in Ontario were highlighted by this review. First, despite evidence supporting the role of the intensivist in guiding the multidisciplinary management of critically ill patients towards improving costs, efficiencies and patient outcomes,[15,16] we found that 26% of medium to large units (≥8 beds) capable of mechanical ventilation did not involve an intensivist in their admission and care decisions. This finding is consistent with evidence from the United States, where it has been demonstrated that less than half of the ICUs had coverage by an intensivist or a dedicated physician.[17] However, before determining the projected workforce needed to staff an expanded number of critical care beds, problems with intensivist shortages, physician burnout, and rising physician costs may lead to further difficulties in the appropriate staffing of current ICUs that lack intensivists.[18,19] Some issues regarding rising physician costs may be mitigated by the potential health care savings generated by intensivist staffing.[20] Furthermore, enhanced intensivist staffing may lead to a decrease in critical care demands by decreasing ICU re-admission rates[21] or by improving utilization of critical care resources. Finally, a multifaceted approach using different strategies (e.g., enhanced nurse or specialized non-physician staffing) and other tools (e.g., automated order sets) may be the most efficient and cost-effective method of improving the process and quality of care in the ICU without requiring additional intensivists.[19,22] Future studies are needed to confirm improved clinical outcomes from these interventions. It is important to point out that our findings with regard to physician-management are limited to the Level 3 units. The extent to

which staffing patterns in Level 2 critical care units impact on efficiencies, costs, and patient outcomes remains uncertain.

Second, we found that a sizable annual investment in critical care services will be needed if critical care resources are going to be maintained for the growing population at the current level and according to existing management practices. This investment will be necessary, not only for operating dollars but also for the retention and recruitment of health care workers. Given the current utilization rate of 90%, our estimated 57% increase in the number of mechanically ventilated beds from 2006 to 2026 is consistent with the recent findings of Needham et al.[23] These authors used population incidence data to predict an 80% increase in the number of ventilated patients from 2000 to 2026, with an annually compounded projected growth rate of 2.3%. We relied on data for calculating projected bed needs that were understood to be from a representative sampling of hospitals; consequently, our methodology is subject to bias. As well, we compared known data from 2006 to projected data in 2026. These factors might account for the difference between our estimate and that of these authors. However, our confirmation that a considerable increase in the number of ventilated beds will be needed in the future, coupled with our data regarding management models, supports growing evidence of a pending "crisis" in providing critical care services to seriously ill patients within the North American context.[8]

Our estimated 57% increase in the number of mechanically ventilated beds from 2006 to 2026 represents a requirement from 2007 through to 2026 for an additional 30 mechanically ventilated beds per year. Under ideal utilization (80%), this number increases to an additional 41 mechanically ventilated beds per year. Given the costly nature of intensive care and the substantial proportion of budgets already allocated to critical care services, finding additional resources to meet this steady rise in demand will be a challenge and is a cause for concern for health regions across the continent. To that end, it may be preferable to implement strategies that make critical care delivery more efficient and cost-effective and directed at patients who are most likely to benefit. These measures might include developing standard of care protocols (e.g., protocols for the prevention of ventilator-associated pneumonia and catheter-related bloodstream infection[24,25]), using medical emergency teams to identify general ward patients at risk for deterioration and admission to a critical care unit,[26] applying clear admission and discharge criteria, and exploring alternate staffing patterns. The Ontario government has already begun to implement some of these measures as part of its Critical Care Strategy (www.health.gov.on.ca/criticalcare), namely, the implementation of medical emergency teams.[27]

The implications of increasing demand in the face of a relatively fixed supply of critical care resources will have a significant impact on both health care providers and critically ill patients. A recent study from the United Kingdom, where ICU beds are chronically lacking, suggests that physicians may develop "prognostic pessimism", leading them to refuse ICU admission to many seriously ill patients.[28] A similar comparison study between Canada and the United States found that elderly patients with chronic medical problems were denied ICU admission more often in Alberta than in Western Massachusetts, with Alberta having 50% fewer ICU beds than Western Massachusetts.[29] It is quite possible, even today, that limited availability of critical care resources impacts on patient access and outcomes. Whether the scarcity of ICU resources in these jurisdictions played a direct role in physician decision-making is unclear. Patient factors, such as gender, may also lead to important differences in critical care access and outcomes.[30] Finally, despite admission to the ICU, the ongoing scarcity of critical care resources may influence decisions regarding end-of-life care and the provision of life support.[31] Future studies are required to ascertain the impact that health care systems with inadequate provision of critical care services have on access to care, end-of-life decision-making, and patient outcomes, particularly in vulnerable populations such as the elderly and patients with chronic medical conditions.[32]

We acknowledge several limitations of the present study. First, using a broad definition of a critical care unit limits comparison with similar studies using various other definitions of a critical care bed. We chose this definition in order to capture the resources that would best inform the critical care transformation project. The second limitation involves the assumptions used to derive our forecasting models. In particular, we defined the age distribution of patients admitted to all critical care units based on data we obtained from a sample of hospitals that may not be representative of the whole. However, our finding is consistent with the report by Needham et al., which described a different methodology for predicting future requirements for mechanical ventilation.[23] Notwithstanding these limitations, the high response rate represents the most complete assessment of critical care resources conducted within the Canadian health system. Additionally, while the data may be specific to Ontario, it is consistent with other reports that highlight the need for significant planning for the delivery of critical care services.[3,8]

In conclusion, the combination of an aging population and inefficiencies in the management of critical care services will not only be a major challenge to the delivery of critical care over the coming years, but will also have a major impact on patients and their health care providers. It is evident that a rather dramatic fiscal investment in the

critical care environment will be needed, together with a significant increase in the number of health care workers. If adequate investments cannot be made, alternatively, or perhaps in parallel, a major reorganization is necessary to improve the methods used to provide critical care services if access to high quality critical care is to be adequately maintained for our population.

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Conflicts of interest None declared.

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