# Care in Canadian ICUs

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# Executive summary

The intensive care unit (ICU) provides critical care to severely ill patients. In 2013–2014, 11% of adult hospital stays in Canada outside of Quebec included time in an ICU. Experts have suggested that an increase in the severity of illness among hospital patients, coupled with Canada's aging population, may contribute to an expected rise in the use of — and, in turn, the cost of — ICUs in the coming decades.[1, 2] The average daily cost of an ICU stay is estimated to be as high as 3 times the average cost of a day's stay on a general ward, as ICU stays are more resource-intensive — from personnel to equipment and medication. For these reasons, it is important to better understand the use of this constrained resource with respect to operating patterns, patient flow, trends in admissions, patient populations and process of care for those treated in ICU.

Using mainly administrative data from the Canadian Institute for Health Information (CIHI), this study examines care in ICUs across Canada, excluding Quebec.

The study's main findings are as follows:

1. The use of ICUs in Canada is increasing faster than acute care hospitalizations overall. In 2013–2014, there were more than 230,800 adult ICU admissions in Canada, an increase of 12% since 2007–2008. During the same time frame, adult hospital admissions increased by 7%.
2. 8 in 10 ICU admissions resulted from urgent hospital admissions. This has implications for patient outcomes, resource utilization and capacity planning.
3. Most ICU beds are in large or teaching facilities, where having enough ICU beds to meet the growing demand is a widespread challenge. On average, large and teaching hospital ICUs operate at about 90% capacity, with periods of overcapacity equivalent to between 45 and 51 days in 2013–2014.
4. A growing number of ICU patients need specialized, resource-intensive care. Invasive ventilation is one of the most common processes of care in ICU, received by 33% of ICU patients in 2013–2014, up from 28% in 2007–2008. The biggest increase was among those who received short-term (i.e., less than 96 hours) invasive ventilation. The continued rise in use for ventilation could place additional strain on ICUs.

ICU capacity is a current and future health system challenge in Canada. The aging population and concerns around the potential increase in severity of illness among hospital patients could place additional demands on Canadian ICUs in the coming decades. This report and its companion products can help inform evidence-based system improvement efforts by providing a baseline of comparable measures of ICU care in Canada. It can also serve as a resource for discussions about advance care planning and goals of care, as well as care plans for the prevention and treatment of chronic conditions.

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# Introduction

The intensive care unit (ICU) is a vital component of acute care in Canada. It is where critically ill patients receive life-supporting care. ICUs are resource-intensive — from personnel to equipment and medication — and therefore costly. ICUs serve a broad range of patients, from those with pre-existing conditions to those with unexpected injuries or illness, as well as those who need support before and after undergoing complex procedures. In 2013–2014, 11% of the more than 2 million adult hospital stays in Canada (outside of Quebec) included time in an ICU. Experts have suggested that an increase in severity of illness among hospital patients, coupled with Canada's aging population, may contribute to an expected rise in use and, in turn, cost of ICUs in the coming decades.[2, 3] Such concerns underscore the increasing importance of understanding the use of ICUs, and the quality of care and outcomes for patients treated in ICU.

There are different types of ICUs that provide care to specific patient populations. Canadian ICUs can be broadly categorized into 3 types: general, specialized, and pediatric and neonatal.

- General ICUs provide care to patients who require intensive care for common medical and surgical reasons.
- Specialized ICUs (e.g., burn, cardiac, neurosurgery, trauma, respirology) provide care to meet the needs of a specific type of illness or injury.
- Pediatric and neonatal ICUs provide intensive care to children and newborns.

Other types of special care units include step-down units (SDUs), which are also typically classified as medical, surgical or combined. These units provide a higher level of care for hospital patients than can be provided in a general inpatient unit.

ICUs use different approaches to organize and manage care needs. Models of care refer to organizational features related to multidisciplinary teams, medical and nursing leadership, communication and collaboration among providers.[4] ICUs are commonly organized around either open or closed admission and discharge models. In an open model, ICU patients are overseen by a primary attending physician (e.g., internist, surgeon, family physician) in consultation with an intensivist (i.e., a specialist in critical care medicine); in a closed model, patients are assigned an intensivist who is responsible for their time in ICU. While the prevalence of these models and their association with outcomes remain unknown, the complexity of ICU care makes the organizational structure an important decision for critical care teams within hospitals.

This CIHI report is focused on adult ICU patients from general and specialized ICUs. It provides high-level information on ICU capacity, trends in overall use and admissions, ICU patient populations and ICU processes of care. This information can be used to facilitate future comparative reporting on measures of ICU care, as well as on ICU operations in general. It can also inform improvement initiatives looking at how care is provided and at outcomes for patients.

## System implications

Aging population

Average daily cost 3× general ward

Long-term planning

Increasingly complex and severely ill

## Study development and methodology

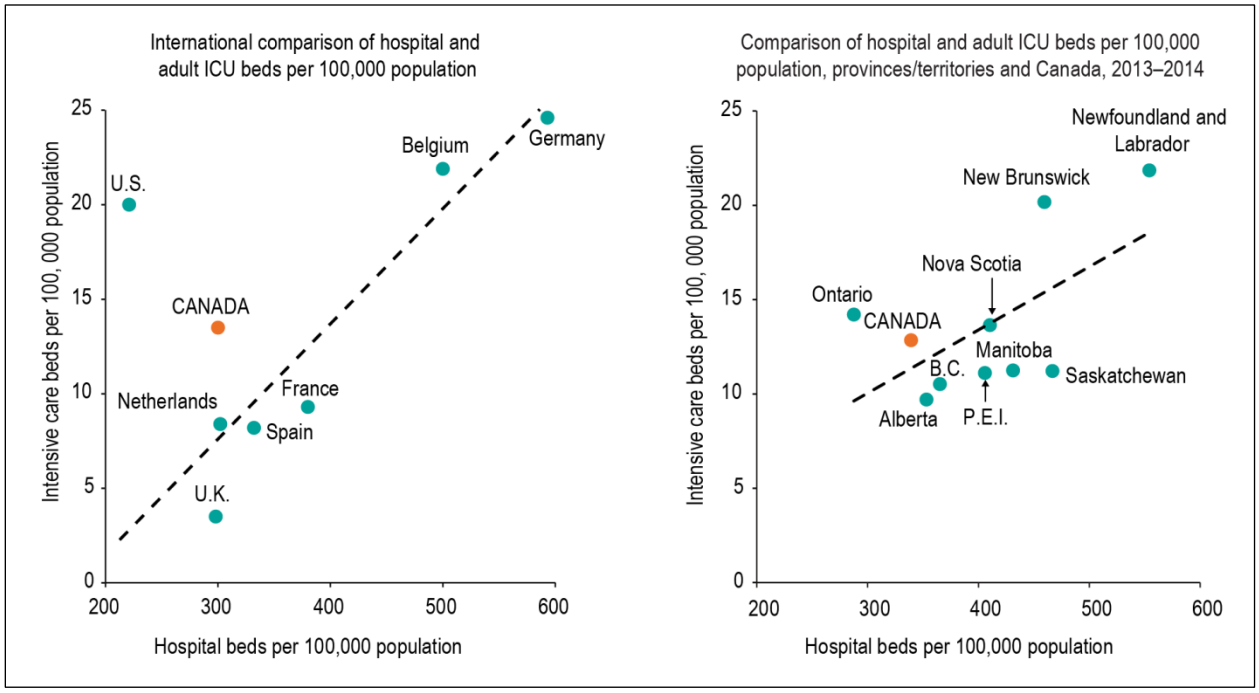
Study development was informed by literature and review of critical care measurement and reporting across Canada, as well as through consultations with experts. Information was gained on critical care reporting at specific hospitals and provinces in Ontario, Manitoba, Alberta and British Columbia, where extensive ICU data is available. Internationally, approaches taken in the United Kingdom and United States were also considered, with experts from abroad providing input and identifying limitations. Based on this input, CIHI's data and standards were used to develop appropriate and consistent measures and definitions for inclusion in this study.

Appendix A provides details on data sources, case selection and study limitations.

# Use of ICUs in Canada

There is substantial global variation in the availability of ICU beds.[5] Analysis for this study estimated that Canada had 12.9 adult ICU beds per 100,000 population in 2013–2014, placing it mid-range of comparable countries (Figure 1). CIHI's findings are consistent with other studies. Canada has more ICU beds per population compared with several western European countries, but fewer when compared with the U.S., Belgium and Germany.[6] The range within Canada across jurisdictions is almost as large (Figure 1).

**Figure 1** Hospital beds and adult ICU beds per 100,000 population, international* and Canada†




**Notes**

* The figure showing international comparisons has been reproduced with permission. Data years range from 2003 to 2005. For more detail, see Wunsch et al. (2008).[6]

† The figure showing comparisons across provinces in Canada is based on 2013–2014 data. The data on hospital beds per population includes information on all acute hospital beds that are staffed and in operation in the fiscal year (including pediatric, obstetric and intensive care beds) from the Canadian MIS Database. The data on adult ICU beds is based on estimates from this study and excludes beds in SDUs. The estimates for New Brunswick (5 facilities) and Nova Scotia (1 facility) include beds in provincially/territorially defined units (PTDUs). The Canada values for both hospital beds and adult ICU beds exclude beds in Quebec and the territories.

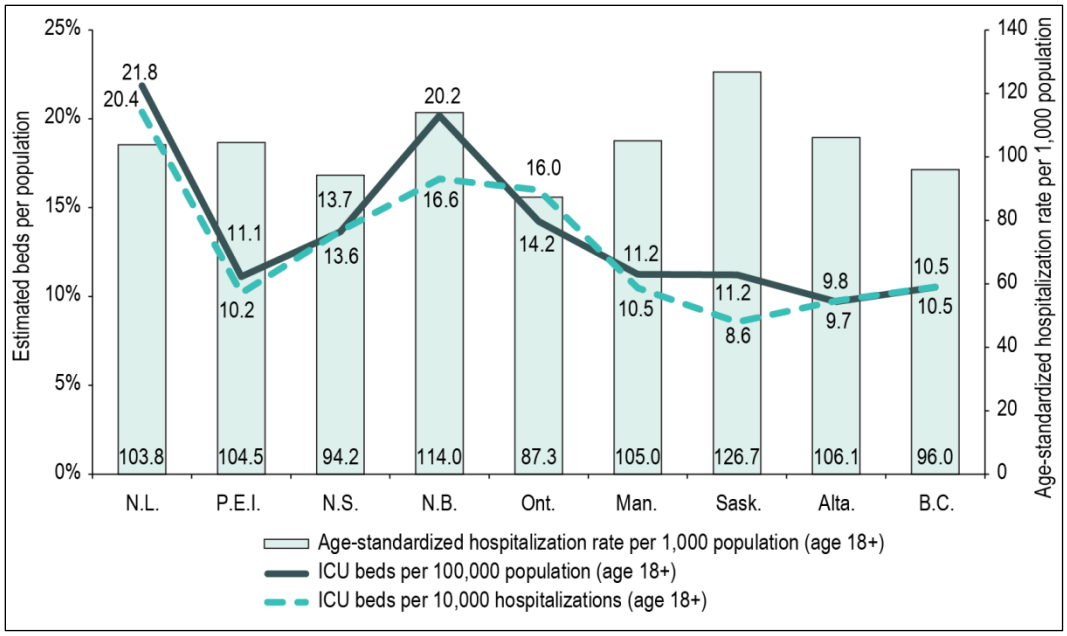
**Sources**

Discharge Abstract Database, 2013–2014 and 2014–2015, and Canadian MIS Database, 2013–2014, Canadian Institute for Health Information; and the 2014 Canadian population from Statistics Canada, Table 051-0001: Estimates of population, by age group and sex for July 1, Canada, provinces and territories. CANSIM database. Accessed June 13, 2016.

# ICU capacity and challenges

As shown in Figure 2, whether ICU capacity is measured as ICU beds per population or per hospitalizations, the pattern of variation across the jurisdictions is similar. However, it is not entirely clear what the relationship is between the number of ICU beds and hospitalization rates. The variation among the provinces coupled with a lack of information on ICU overuse and underuse makes it difficult to determine the ideal number of ICU beds for each jurisdiction. For example, it is unknown whether there were patients in need of ICU services who were never admitted because the ICU was at full capacity or conversely whether there were patients who stayed in ICU beds longer than necessary because no general ward bed was immediately available.

**Figure 2** Adult ICU beds per 100,000 population, adult ICU beds per 10,000 hospitalizations, age-standardized hospitalization rate, by province, 2013–2014




**Notes**

Age-standardized hospitalization rate: The crude hospitalization rate was adjusted for any differences in the age distribution across the provinces using direct standardization.

Age-specific hospitalization rates in each province were weighted by the proportion of individuals in each age group (for the province) from the external reference population (i.e., the standard) to create the age-standardized hospitalization rates.

Age standardization was completed using the 2011 Canadian population as the reference population.

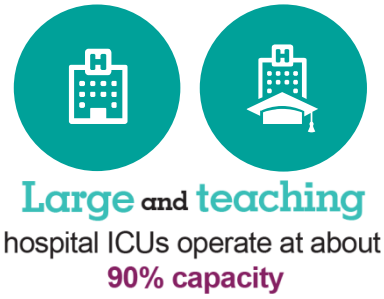
Data on adult ICU beds is based on estimates from this study and excludes beds in SDUs.

Estimates for New Brunswick (5 facilities) and Nova Scotia (1 facility) include beds in PTDUs.

**Sources**

Discharge Abstract Database, 2013–2014 to 2014–2015, Canadian Institute for Health Information; and 2014 Canadian population from Statistics Canada, Table 051-0001: Estimates of population, by age group and sex for July 1, Canada, provinces and territories. CANSIM database. Accessed June 13, 2016.

Previous research has shown that Canadian ICUs are well utilized.[6] Using hospital data from 2013–2014, this study showed similar findings. Occupancy rates for Canadian ICUs were calculated by comparing the estimated number of ICU beds for each hospital with the number of ICU patients each hour (methodology available upon request). Half of ICUs show an annual average occupancy above 80%, but this varies widely by hospital type and between urban and rural settings.

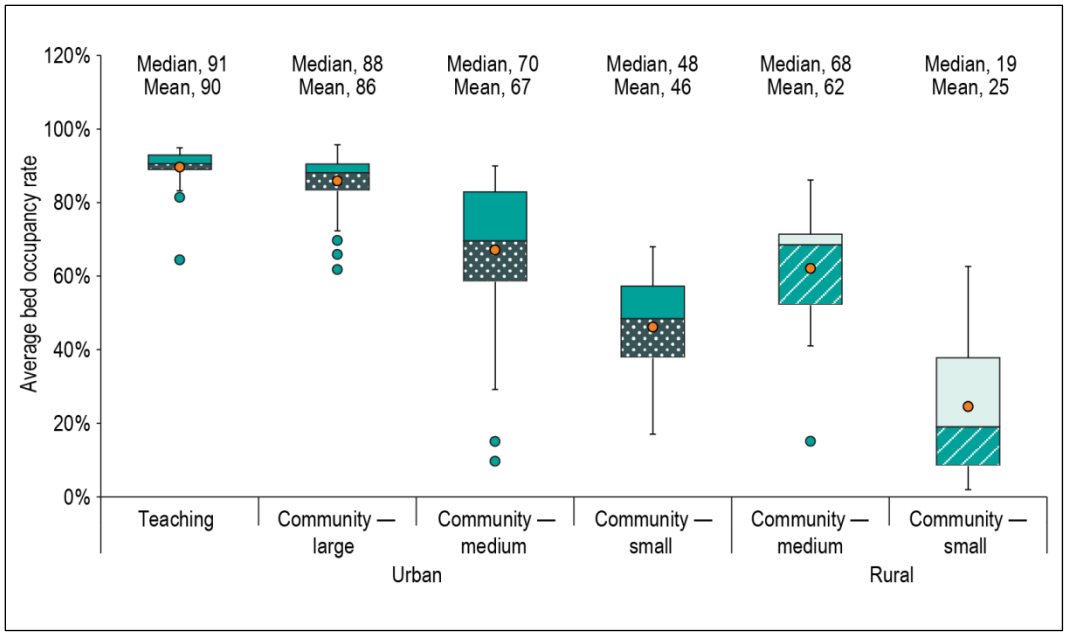



Overall, the ICUs of teaching and large facilities in urban areas have the highest average occupancy rate. Estimated average occupancy was highest in teaching (90%) and large (86%) facilities, predominantly located in urban areas, compared with smaller facilities (50%) (Figure 3). Larger facilities also tended to exceed occupancy thresholds more often. Large and teaching hospital ICUs, on average, were over capacity for the equivalent of 45 to 51 days in 2013–2014.

Our expert advisors for this study suggest that the implications of being over capacity for an extended period of time on care delivery may include

- The cancellation of planned (elective) procedures and surgeries;
- The inability to admit or a delay in admitting new or unplanned patients to the ICU;
- Early ICU discharge of patients who would normally have remained in the ICU to accommodate a patient who is more critical;
- Transfers to other acute care facilities; and
- Night discharge to the general ward.[7]

## Figure 3 ICU occupancy by facility type, rural and urban areas, 2013–2014




**Notes**

The bed occupancy rate (BOR) is equal to the number of beds occupied divided by the estimated total number of ICU beds.
The BOR was calculated for each hour in the fiscal year for all facilities in the sample, and the annual average BOR across the hours in the fiscal was found for each hospital. The hospital average BORs were then plotted by peer group (i.e., teaching, community — large, etc.) for each area of residence (urban or rural) creating 6 residence peer groups.
The orange dots mark the mean of the hospital average BORs in each boxplot. 2 coloured boxes make up the core of the boxplot: the bottom of the lower box shows the first quartile (Q1), while the top of the box shows the median of the hospital average BORs in the peer-residence group; the top of the upper box shows the third quartile (Q3). The bottom whisker shows the minimum, while the top whisker shows the maximum of the hospital average BORs in the group. The green dots denote outliers.
Data excludes the territories; excludes beds in SDUs but includes beds in PTDUs in New Brunswick (5 facilities) and Nova Scotia (1 facility).

**Source**

Discharge Abstract Database, 2013–2014 to 2014–2015, Canadian Institute for Health Information.

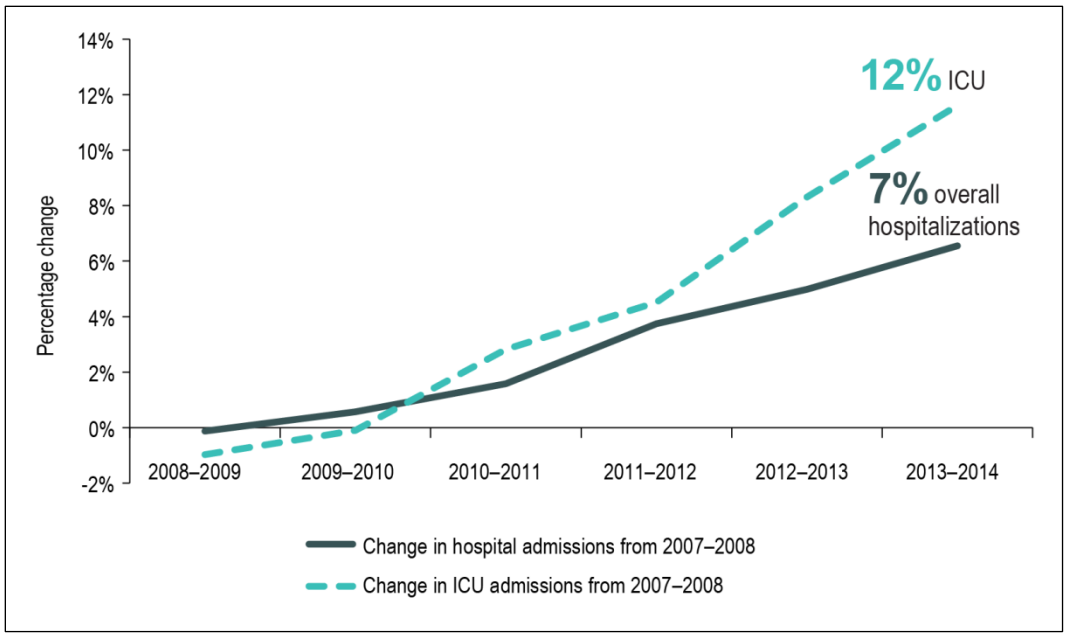
This study found that there was a noticeable increase in patients discharged from ICUs during busy periods — both to the general ward of the same hospital and to the ICU of another hospital altogether. While some transfers may be clinically necessary to provide care at a specialist centre, non-clinical transfers may be required when there is lack of capacity. When ICUs were over their estimated capacity, the ratio of discharges to admission was nearly 2 to 1 (1.7), compared with approximately 1 to 1 (0.8) when the ICUs were within capacity. Similarly, the average number of transfers per hour from ICUs to other acute care facilities also doubled during periods of overcapacity. While only 15,546 transfers occurred overall, 2,220 took place while ICUs were over capacity. It is not clear what, if any, effects this has on patient care and outcomes.

There are other measures that could also speak to ICU capacity. Readmissions occurring within 48 hours can signal premature ICU discharge and may have been associated with poorer outcomes. This study found that Canada's overall 48-hour ICU readmission rate was at the low end of the range at 1% but was still in line with the 1% to average of 8% found in the literature.[8, 9] Night discharges are similarly not recommended due to issues of handover and staffing difference at night. Canada's rate of night discharge, at 7%, was higher than those reported in other studies.[10] Capacity and strain in ICUs does have long-term implications for critical care delivery in Canada, including concerns among experts about meeting the needs of an aging and more severely ill population requiring additional ICU services.

# Trends and ICU admissions

The use of ICUs is increasing faster than overall hospital admissions. In 2013–2014, there were more than 230,800 adult ICU admissions in Canada, outside of Quebec. This number is up from the more than 206,800 adult ICU admissions in 2007–2008, and represents an increase of 12% over this period (versus 7% for overall hospital admissions) (Figure 4).

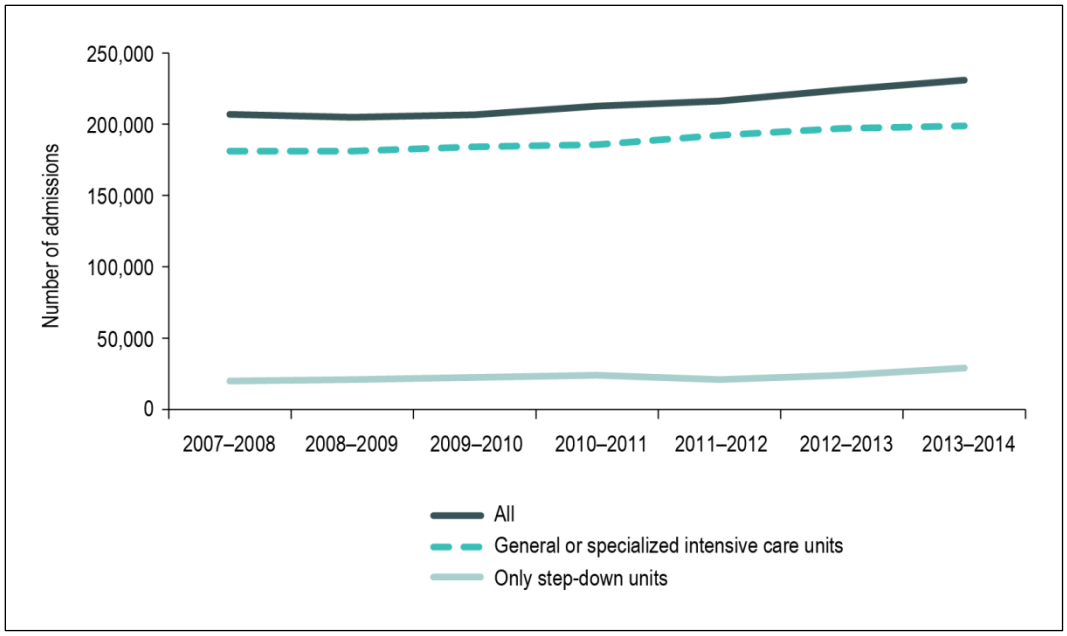
**Figure 4** Change in ICU and hospital admissions for adult patients in Canada, 2007–2008 to 2013–2014




**Notes**
ICU admissions includes stays in SDUs and PTDUs.
Data excludes hospital and ICU admissions for Quebec but includes the territories.
**Sources**
Discharge Abstract Database, 2007–2008 to 2014–2015, and Ontario Mental Health Reporting System, 2007–2008 to 2013–2014, Canadian Institute for Health Information.

The biggest relative growth in ICU usage was among patients admitted exclusively to a step-down unit (SDU) (i.e., with no stay in any other type of ICU), increasing by 46%, from 19,861 to 29,037 (Figure 5). This may be due to more SDUs opening over time or ICU use being managed differently than in the past. Studies have found that SDUs are commonly used without prior admission to ICU. For example, Hilton and colleagues found that 33% of overall patients were admitted to an SDU from the emergency department (ED) (8%) or general wards (25%), and Lucena and colleagues concluded that 77% of SDU patients were admitted from the ED (25%) or general wards (52%).[11, 12] SDU patients are often those with acute respiratory compromise needing non-invasive ventilator support or those requiring renal replacement therapy.[13]

**Figure 5** Trend in overall adult ICU admissions, 2007–2008 to 2013–2014




**Note**
"All" includes stays in only PTDUs.
**Source**
Discharge Abstract Database, 2007–2008 to 2014–2015, Canadian Institute for Health Information.

Studies suggest that population growth, increases in severity and complexity of critical illness, and Canada's overall aging population will likely all contribute to ICUs' challenges in meeting future demand.[1–3] Already there are often periods when ICUs across Canada are operating over capacity, especially in teaching and large facilities. As demand increases, the ability to measure and report on ICU care will become increasingly important to ensuring sustainable long-term solutions.

# Admission to the ICU

Patients' admissions to the ICU typically result from one of the following scenarios:

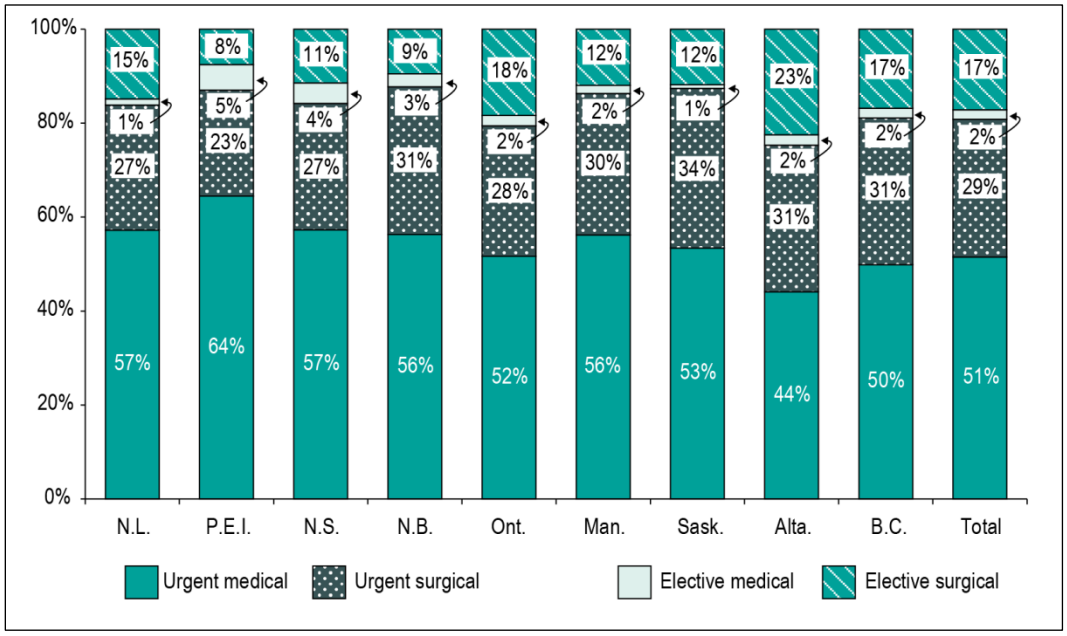
1. **Urgent or emergent** — Treatment of a critical illness that requires urgent care at the time of admission, such as a trauma patient from a motor vehicle collision. Urgent admissions can also stem from an unexpected deterioration in a patient's condition, such as a patient who develops pneumonia while admitted to hospital for a hip fracture repair.
2. **Planned or elective** — Treatment following a medical procedure that is scheduled in advance. An ICU stay is an anticipated part of the patient's hospitalization.

For 8 in 10 ICU patients, their ICU stay was associated with an urgent or emergent admission to the hospital. About half (51%) were urgent medical patients, with variation across provinces ranging from 44% to 64% (Figure 6). When adjusted to remove planned cardiac cases, 85% of all ICU admissions were from urgent hospital admissions.

**8** out of **10** were urgent unplanned admission

Differences across provinces likely reflect patient needs and the way care is organized. For example, many cardiac surgeries are planned and some jurisdictions regularly send patients to other provinces for such procedures. For example, cardiac patients who live in Prince Edward Island are commonly treated in Nova Scotia or New Brunswick.

**Figure 6** Hospital admission category for adult medical or surgical ICU patients by province, 2013–2014




**Notes**
Data is based on admission category information at the time of hospital admission.
An elective hospital admission could result in an urgent admission to an ICU. As such, the number of urgent admissions to ICUs may be higher.
Data excludes admissions to only SDUs but includes admissions to only PTDUs in New Brunswick (5 facilities) and Nova Scotia (1 facility).
Percentages may not add to 100% due to rounding.
**Source**
Discharge Abstract Database, 2013–2014 to 2014–2015, Canadian Institute for Health Information.

Given that ICUs typically operate at close to capacity levels, there is limited flexibility to accommodate an unexpected surge in volume. Surges can be caused by seasonal illnesses, disasters or pandemics. During the second wave of swine flu (H1N1) in 2009, hospitals accommodated large numbers of H1N1 patients by managing the admission of patients not requiring H1N1 care (limiting their admissions to both ICU beds and the general ward), as well as increasing ventilator capacity.[14] This pandemic and the strain it placed on ICUs across Canada demonstrate the importance of understanding ICU bed capacity and the ability of hospitals to react to long-term population-based needs as well as to surges.

## ICU at end of life

For some patients, the ICU can be part of appropriate end-of-life care and offer services that are specific to their needs to be comfortable. However, if appropriate end-of-life care could be administered in less intensive care settings, the literature suggests that there is an opportunity to reduce costs in ICU.[15] Critically ill patients at the end of life should have discussions about their preferences with their care team and family, ensuring that advance directives and goals of care are understood. Importantly, a U.S.-

based study found that only 5% of ICU patients had advance directives or end-of-life plans and that the presence of these plans did not have an impact on the care provided.[16] While ICU-specific Canadian data was not available for this current study, a recent CIHI study found that Canadians are in general more likely than those from other countries to have advance care plans.[17] Approximately 75% of long-term care patients in Canada have a do not resuscitate order, while 20% have a do not hospitalize order. Further, the data shows that those wishes were respected. Discussions about advance directives and goals of care enable both care team and family to advocate for the patients' wishes when they are not able to do so themselves. Initiatives to raise awareness and support such decision-making could alter the dynamics of ICU care in Canada by shifting patients to other care settings at the end of life.

# ICU patient populations and process of care

## Types of patients most commonly seen in ICUs

Many of the conditions that lead to ICU admission are preventable and, if treated earlier, can be managed in other less intensive settings. In 2013–2014, there were more medical (54%) than surgical (46%) patients overall in Canadian ICUs. Medical patients represented a greater proportion of ICU patients in small (90%) and medium-sized (77%) hospitals, compared with large (62%) and teaching (37%) hospitals. Evidence exists that through optimal management strategies and public health knowledge on prevention and management, some critically ill patients with chronic conditions could avoid or limit the need for acute care services.[18]

Examining the profile of ICU patients over time and across jurisdictions can facilitate an understanding of potential variations in patient needs and demand for services resources. The patients admitted to ICUs in 2013–2014 were similar to those admitted in 2007–2008 with respect to age, gender, neighbourhood income, place of residence and hospital peer group. The profile was also largely similar across provinces. Additional descriptive detail can be found in the data tables that accompany this report.

### What is CMG+?

The Case Mix Group+ (CMG+) methodology is designed to aggregate hospital inpatients who have similar clinical and resource-utilization characteristics. Case Mix Groups (CMGs) are derived primarily from a combination of diagnoses and interventions. The resulting diagnostic CMGs are based on patients' overall hospital admissions; they are not specific to the ICU.

CMG+ was used in this analysis to identify the most common medical and surgical CMGs among ICU patients within each year. This has allowed us to report on changes in ICU case mix over time.

Table 1 shows the top 10 medical CMGs among ICU patients in 2013–2014 and the change in volume since 2007–2008. Cardiac illnesses accounted for about 1 in 3 medical ICU patients in 2013–2014, with myocardial infarction and arrhythmia remaining the highest volume throughout the study period.

## Table 1 Top 10 medical CMGs (conditions) among adult ICU patients, 2007–2008 and 2013–2014, Canada

| | Top medical conditions | Volume (percentage of all medical ICU patients) 2007–2008 | Volume (percentage of all medical ICU patients) 2013–2014 | Change ($p<0.05$) in proportion, 2007–2008 to 2013–2014 |
|---|---|---|---|---|
| 1 | Myocardial infarction/ shock/arrest | 19,773 (19%) | 14,911 (13%) | ↓ |
| 2 | Arrhythmia | 7,412 (7%) | 6,874 (6%) | ↓ |
| 3 | Heart failure | 5,853 (6%) | 5,821 (5%) | ↓ |
| 4 | Chronic obstructive pulmonary disease (COPD) | 5,051 (5%) | 5,691 (5%) | ↔ |
| 5 | Other/unspecified sepsis | 3,044 (3%) | 5,137 (5%) | ↑ |
| 6 | Poisoning/toxic effect of drug | 3,947 (4%) | 4,263 (4%) | ↔ |
| 7 | Respiratory failure | 2,378 (2%) | 4,046 (4%) | ↑ |
| 8 | Unstable angina/arteriosclerotic heart disease (ASHD) | 6,816 (6%) | 3,685 (3%) | ↓ |
| 9 | Other/miscellaneous cardiac disorder | 2,691 (3%) | 3,389 (3%) | ↔ |
| 10 | Diabetes | 2,413 (2%) | 2,962 (3%) | ↑ |

**Notes**
Data is based on the CMG+ 2014 methodology year.
Data excludes admissions to only SDUs but includes admissions to only PTDUs.
**Source**
Discharge Abstract Database, 2007–2008 to 2008–2009 and 2013–2014 to 2014–2015, Canadian Institute for Health Information.

Chronic diseases, such as diabetes or COPD, are best managed through primary health care or in acute services as necessary to avoid the need for ICU admission. This study found that 2,962 patients were treated for diabetes in the ICU in 2013–2014, based on the most responsible diagnosis for their hospital admission. Diabetes is a chronic disease that inhibits the body's ability to produce insulin or appropriately use the insulin it produces.[19] Beyond the diagnoses identified in this study, diabetes is a very common underlying diagnosis in many ICU patients. In 2013–2014, 26% (53,146) of patients treated in the ICU were identified as having diabetes (i.e., diabetes was among the patient's reported diagnoses). Diabetes can lead to cardiac and vascular disease, kidney failure and serious infections, among other illnesses. In the ICU, this condition complicates care strategies and may increase the severity of the primary diagnosis. For example, one study found that 28% of patients admitted for sepsis were also diagnosed with diabetes.[20] Literature shows that for patients with diabetes, hospitalization can disrupt the "outpatient balance of medications, diet and exercise" and lead to the requirement of longer and more critical care.[21]

The most common surgical reasons for admission to the ICU included percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG). Together, they accounted for 30% of all surgical patients. Table 2 shows the top 10 surgical CMGs by patient volume in 2013–2014 and, by comparison, what those volumes were 7 years previously. The top 4 surgical CMGs (procedures) were all cardiac-related and had been consistent since 2007–2008.

**Table 2** Top 10 surgical CMGs (procedures) among adult ICU patients, 2007–2008 and 2013–2014, Canada

| | Top surgical conditions | Volume (percentage of all surgical ICU patients) 2007–2008 | Volume (percentage of all surgical ICU patients) 2013–2014 | Change (<0.05) in proportion, 2007–2008 to 2013–2014 |
|---|---|---|---|---|
| 1 | Percutaneous coronary intervention | 14,145 (16%) | 16,924 (17%) | ↑ |
| 2 | Coronary artery bypass graft | 15,174 (17%) | 13,410 (13%) | ↓ |
| 3 | Cardiac valve replacement | 5,748 (6%) | 8,014 (8%) | ↑ |
| 4 | Pacemaker implantation | 3,986 (4%) | 4,434 (4%) | ↔ |
| 5 | Colostomy/enterostomy | 3,009 (3%) | 2,908 (3%) | ↔ |
| 6 | Abdominal aorta intervention | 2,732 (3%) | 2,210 (2%) | ↓ |
| 7 | Non-major excision/repair of upper gastrointestinal tract | 1,926 (2%) | 2,188 (2%) | ↔ |
| 8 | Open large intestine/rectum resection without colostomy | 2,833 (3%) | 2,184 (2%) | ↓ |
| 9 | Multisystem/unspecified site infection with intervention | 1,213 (1%) | 1,760 (2%) | ↑ |
| 10 | Major thoraco-abdominal/vascular intervention with trauma/complication of treatment | 1,612 (2%) | 1,575 (2%) | ↔ |

**Notes**
Data is based on the CMG+ 2014 methodology year.
Data excludes admissions to only SDUs but includes admissions to only PTDUs.
**Source**
Discharge Abstract Database, 2007–2008 to 2008–2009 and 2013–2014 to 2014–2015, Canadian Institute for Health Information.

Almost all (94%) of these cardiac surgical patients received care in teaching or large hospitals, reflecting the concentration of care in centres of excellence. Many patients undergoing PCI are admitted to specialized ICUs such as coronary care units, and patients undergoing cardiac surgery are admitted to a cardiac surgery ICU specific to cardiac care, which is not available in every hospital.

# ICU processes of care

ICU patients have a wide range of diagnostic and therapeutic needs. Some patients need close monitoring of vital signs (e.g., heart rate and rhythm, blood pressure, respiratory rate, intracranial pressure) immediately after a major surgery or serious injury. Others may have an electrolyte or metabolic disturbance that requires close monitoring as the underlying condition is corrected. Patients with respiratory failure often require mechanical ventilation to support their breathing; other patients may require intravenous medications to maintain their blood pressure or heart rate. Kidney dialysis is used for patients with end-stage renal disease to remove waste, salt and extra water, to control blood pressure and to maintain safe levels of various chemicals in the blood. Characterized in the literature as processes of care, these treatments play a key role in the prognosis for many patients.

## Patient care measures in Canada's ICUs

Measurement of ICU care contributes to understanding variation in critical care across Canada and supports evidence-based decision-making. For this study, several measures of care in Canada's ICUs were developed through literature review and extensive consultations across the country. Results show that Canada performs generally within the range of rates published for other western countries. While the international findings provide a range within which to understand Canada's findings, comparisons should be made with caution as there is variation in data sources and methodology.[6] Additionally, this study reports unadjusted or crude rates — due to data limitations — while many published studies, including those referenced below, adjust for severity of illness using ICU-specific severity or physiologic scores.

The measures of patient care analyzed in this study are as follows:

## ICU mortality (overall 9%)

This measures the proportion of ICU stays where a patient died in the ICU, an outcome more common in ICU patients than in general ward patients due to the severity of illness and complexity of care required among these patients. The overall unadjusted ICU mortality in this study was 9%. Internationally, there is wide variation in mortality rates, from 6% in Germany and 10% in the U.S., to 29% in the U.K.[22, 23]

## 48-hour ICU readmissions (overall 1%)

This measures the proportion of ICU episodes in which patients were discharged to the general ward and then readmitted to an ICU within 48 hours. Readmissions occurring within 48 hours can signal premature discharge from the ICU, which is associated with poorer outcomes.[8] ICU patients requiring readmission have higher mortality rates and longer lengths of hospital stay, and are linked to higher costs.[24] This study found that Canada's overall 48-hour ICU readmission rate was at the low end of the range, at 1%, but was still in line with the 1% to average of 8% found in the literature.[8, 9]

## Length of ICU stay (overall approximately 3 days)

Factors that increase length of stay in the ICU include challenges with communication among and between care teams, and the absence of full-time ICU physicians. As such, this measure has implications on ICU resources and costs.[25] At approximately 3 days, this measure for Canada falls within the same range as that for European nations, with average lengths of ICU stay between 2.8 and 3.7 days.[26]

## Invasive ventilation (overall 33%)

Invasive ventilation is a marker of clinical severity, involving a breathing tube in the trachea. There is variation in the use of invasive ventilation; this is commonly driven by patient mix. In Canada, 33% of patients with an ICU stay are invasively ventilated. International studies have reported a wide range, with lower rates in France (19%)[27] and higher usage in the U.S. (39%).[28]

## Night discharge from ICU (overall 7%)

This measures the proportion of ICU stays in which patient discharges from the ICU to the general ward occurred between 10:00 p.m. and 6:59 a.m. ICU patients discharged overnight have significantly poorer outcomes and are also more likely to be discharged prematurely from the ICU.[7] In Canada, 7% of patients were discharged from an ICU at night. Internationally, there is wide variation in night discharge rates, from 6% in Australia to 18% in the U.K.[10, 29]

## Transfers (overall 9%)

This measures the proportion of ICU stays resulting in a transfer to another acute care hospital. Inter-hospital transfers from ICU are an operational measue that may indicate ICU resource availability and potential for elevated risk to patients. Transfers can be the result of a number of factors such as access to care, capacity constraints or availability of specialized treatment. In Canada, 9% of ICU patients were transferred. Internationally, there is a wide variation in transfers, from 6% in the U.S. to 23% in the U.K.[23]

Detailed information on each of the above measures for Canada at jurisdictional and regional levels is available in the companion data tables to this report.

This section focuses on one common ICU process: ventilation. It describes the patients involved and highlights the differences over time and across jurisdictions.

## Use of invasive ventilation

Mechanical ventilation is a life-saving or life-supporting treatment delivered in ICUs. There are different mechanisms to provide mechanical ventilation: invasive ventilation, where a breathing tube is inserted into the trachea, or non-invasive ventilation through the use of a tight-fitting mask to the nose and mouth. Invasive ventilation is common in Canadian ICUs, with 33% of patients requiring invasive ventilation during their ICU stay. This is in line with rates reported in the U.S. of patients ventilated at any given time, ranging from 21% to 39%.[28] The cost to the system and patients can be high, with studies showing links to an increase in mortality and adverse effects. The ventilation itself was estimated at $1,522 per day (adjusted for patient and hospital characteristics) in a 2005 U.S. study, and at 2,110 euros per day (about CA$3,100) in a 2006 European evaluation.[30, 31]

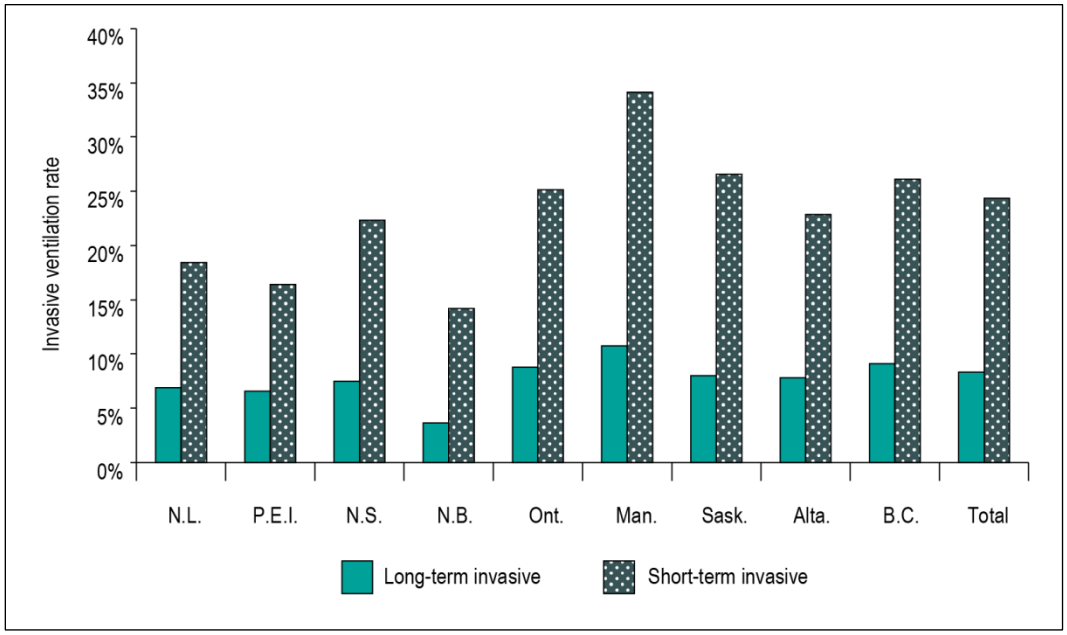
In Canada, the availability of ICU beds with ventilation capacity varies across jurisdictions (5.5 per 100,000 in the territories to 19.3 per 100,000 in Newfoundland and Labrador).[32] At the same time, some experts have suggested that the use of ventilation is expected to increase over time. An Ontario study predicted that based on use in 2006, the demand for invasive ventilation is forecast to increase by 57% by 2026, requiring an estimated 810 additional beds in Ontario alone.[33]

The percentage of non-ICU patients who received invasive ventilation is highest in teaching hospitals, which could reflect that teaching hospitals have more capacity than other hospitals to ventilate outside of the ICU.[32]

Due to its intrusiveness and duration of use, invasive ventilation is associated with increased risk of complications such as pneumothorax, ventilator-associated pneumonia, decreased cardiac output, oxygen toxicity and acute lung injury/acute respiratory distress syndrome.[34] The length of time a patient is on ventilation can have important implications for outcomes, with those needing longer durations of ventilation having worse outcomes.[35, 36] Based on Canadian Classification of Health Interventions codes, long-term invasive ventilation is defined as ventilation equal to 96 hours or longer; short-term invasive ventilation is defined as less than 96 hours. In 2013–2014, more than 65,500 (33%) of ICU patients were invasively ventilated (49,100 as short-term ventilation and 16,800 as long-term ventilation).

As shown in Figure 7, the use of invasive ventilation varied across provinces. The rate was highest in Manitoba (45%) and lowest in New Brunswick (18%). The difference in rates likely reflects differences in patient case mix, facility types and the organization of critical care services within each province.

## Figure 7 Variation in rate of invasive ventilation (short and long term) among ICU patients, by province, 2013–2014




**Notes**
The total excludes Quebec but includes the territories.
The data excludes patients admitted only to SDUs but includes admissions to only PTDUs in New Brunswick (5 facilities) and Nova Scotia (1 facility).
**Source**
Discharge Abstract Database, 2013–2014 to 2014–2015, Canadian Institute for Health Information.

From 2007–2008 to 2013–2014, the biggest increase in the use of invasive ventilation occurred among those who received short-term ventilation (Table 3).

**Table 3** Number of ICU patients by ventilation status, Canada, 2007–2008 to 2013–2014

| Ventilation category | 2007–2008 | 2008–2009 | 2009–2010 | 2010–2011 | 2011–2012 | 2012–2013 | 2013–2014 |
|---|---|---|---|---|---|---|---|
| Short-term, invasive ventilation (less than 96 hours) | 38,673 | 39,313 | 41,963 | 43,699 | 46,230 | 47,534 | 49,101 |
| Long-term, invasive ventilation (96+ hours) | 14,494 | 15,307 | 16,143 | 15,899 | 16,348 | 16,700 | 16,826 |
| No ventilation or non-invasive ventilation | 130,897 | 126,427 | 123,138 | 126,096 | 129,666 | 132,787 | 132,859 |

**Notes**
Data excludes Quebec but includes the territories.
Data excludes patients admitted only to SDUs but includes admissions to PTDUs in New Brunswick (5 facilities) and Nova Scotia (1 facility).
**Source**
Discharge Abstract Database, 2007–2008 to 2014–2015, Canadian Institute for Health Information.

Among all surgical patients admitted to the ICU, 42% required invasive ventilation — almost double that of medical patients (24%). This likely reflects the continuation of ventilation from the operating room into the ICU. In line with findings from the literature that show higher mortality for invasively ventilated patients, in 2013–2014, 19% of invasively ventilated patients died in the ICU, compared with 4% of patients who were not ventilated or received non-invasive ventilation. Rates of invasive ventilation differed by age and sex, and by size of hospital (detailed information is provided in the companion data tables that accompany this report).

Invasive ventilation is a critical process of care administered in the ICU. The continued rise in use of this process could place additional strain on ICUs in the coming decade. Alternative settings for invasive ventilation and support for the management of chronic diseases in less resource intensive environments would help to address the forecast growth.

# Costs

ICUs are a costly resource because they require high staff-to-patient ratios for intensive patient monitoring and complex treatment. Although a small number of hospitalizations involve ICU stays, these ICU stays are responsible for a substantial portion of hospital resources.[37] On average, the daily cost of an ICU stay is as high as 3 times that of stays in general hospital wards across Canada ($3,592 versus $1,135). International studies have reported large variations in the cost per ICU patient admission. Germany, Italy, the Netherlands and the U.K. have an estimated ICU cost per day that ranges from 1,168 to 2,025 euros,[38] while a U.S. study has reported that ICU hospitalizations start at a minimum of US$1,783 per hospitalization.[39] These differences have been attributed to a number of factors, including technology, differences in staffing ratios, treatment options and differing costing methodology across countries.

In the current study, ICU costs in Canada were found to vary by hospital location, type of hospital and type of patient. Table 4 shows the differences in ICU and general ward costs by hospital type. ICU beds are consistently more expensive in every hospital type than a general ward bed, but teaching hospitals ($4,186) have the highest daily costs for an ICU bed. Understanding the costs associated with ICUs reinforces the importance of effectively managing chronic conditions in the community, because they increase clinical complexity.

**Table 4** Average* daily cost for stay in ICU and general ward by hospital type, 2013–2014

| | All | Teaching | Community — large | Community — medium | Community — small |
|---|---|---|---|---|---|
| **Average cost per day in ICU** | $3,592 | $4,186 | $3,639 | $3,242 | $3,494 |
| **Average cost per day on general ward** | $1,135 | $1,492 | $1,032 | $1,021 | $1,135 |

**Note**

* Average is based on costs across individual facilities within each hospital type, where data is available.

**Source**

Canadian MIS Database, 2013–2014, Canadian Institute for Health Information.

# Conclusion

This report and its companion products are intended to provide a basis for comparative reporting on ICUs. The findings provide high-level information on several aspects of ICUs in Canada: their capacity and use, trends in admissions, patient populations and processes of care. Across Canada, outside of Quebec, the use of ICUs appears to be increasing faster than overall hospital admissions. Since 2007–2008, there has been a 12% increase in admissions to ICU, and this trend will likely continue with the aging of Canada's population and the general increase in the severity of illnesses of hospital patients.

The findings highlight that ICU capacity challenges exist. At 12.9 adult ICU beds per 100,000 population, Canada's ICU capacity is in the mid-range of comparable countries. However, there is wide variation across the country. Larger hospitals in urban areas account for the majority of ICUs and ICU beds; in these facilities, estimated bed capacity was most often exceeded. On average, large and teaching hospital ICUs operate at about 90% capacity, with periods of overcapacity equivalent to between 45 and 51 days in 2013–2014.

Further, during periods of high demand, there is a noticeable increase in markers of system stress, including an increase in ICU discharges. This increase was seen in patients discharged to the general ward of the same hospital and to the ICU of another hospital.

8 in 10 ICU patients had an unplanned hospital admission, requiring ICUs to have capacity for admitting those patients without delay. This study found an increased use of step-down units in recent years, possibly in response to the capacity pressure these urgent cases place on admissions. It is not yet clear what effect the capacity issues may have on patient care and outcomes, or on the experience of care for patients and their families. Increasing the supply of ICU beds could help address an aging population and more acutely ill patients. However, some experts suggest that this approach could create more inefficiencies in the use of critical care services or contribute to the overuse of ICUs.[40]

ICU patients are most commonly receiving care for cardiac system illnesses, pulmonary system illnesses or neurologic disorders. The complexity of illness among patients in Canada's ICUs may intensify and could, in part, be driven by expected increasing challenges with managing chronic conditions such as diabetes and COPD.[2] The ability to support the prevention and care of such illnesses and other concurrent chronic conditions in other settings, such as the community or general ward, would not only improve patient care and outcomes but also reduce stress on ICUs. Invasive ventilation is one of the most common processes of care provided in the ICU and is considered by many experts to be a marker of illness severity. The use of invasive ventilation increased over the study period, with 33% of ICU patients receiving invasive ventilation in 2013–2014, up from 28% in 2007–2008. This has important implications for understanding patient complexity, outcomes, resource utilization and capacity planning in the short and long terms.

A number of strategies might be explored to prepare for the increase in ICU care as Canada's population ages. Preventing the onset of chronic conditions is an effective way to reduce the burden of disease on patients and the health care system. When illness does become critical, advance care planning and goals of care discussions can ensure that care delivery reflects patient and family preferences by detailing their wishes, including those who may not want aggressive care at the end of life. Other system-wide changes may be considered, such as reorganizing or possibly increasing the supply of ICU beds in jurisdictions according to evidence of demand–capacity stress.

Developing and reporting on comparable capacity and quality of care indicators and benchmarks that account for severity of illness could inform patient pathway decisions and facilitate best-practice discussions across jurisdictions. The geographic allocation of ICUs — by specialty or by acuity — is heavily influenced by local patient populations, hospital capacity and historical precedence. Well-coordinated and less siloed care delivery could contribute to system-level improvements for the care of critically ill patients. This report and its companion products can help inform evidence-based system improvement efforts by providing a baseline of comparable measures of ICU care in Canada.

# Appendix A: Data sources, case selection and study limitations

This study uses data from CIHI's Discharge Abstract Database (DAD), primarily from 2013–2014 to 2014–2015, to identify discharges from ICUs between April 1, 2013, and March 31, 2014. The study is based on abstracts for patients age 18 and older at the time of ICU admission, and excludes admissions to neonatal and pediatric ICUs. For the historical analyses, DAD data for 2007–2008 to 2011–2012 was used.

The DAD allows for the collection of specific information for up to 6 ICU admissions to be captured on one abstract. This information includes ICU admission/discharge date/time, type of ICU and death in ICU. These data elements and other patient clinical information in the DAD were used in the analysis of ICU utilization and type of hospital admission, as well as in the analysis of patient clinical groups, process of care and outcomes. Analyses of capacity and beds used the date/time data to derive ICU census information, which was then used to estimate the number of beds. The same information was also used for operations measures such as bed occupancy rates. Please note that for the beds analyses, no exclusions were made based on patient's age in order to accommodate cases where a pediatric patient might have stayed in a non-pediatric adult ICU bed.

Additional information on cohort selection and study methodology is available upon request.

## Study limitations

There are several limitations that could affect how the findings from this study are interpreted. Examples of these limitations are noted below:

The measures reported are crude and have not been adjusted in any way due to lack of data on severity of illness or other physiological scores (e.g., APACHE, MODS, MPM). These scores are widely used for the purposes of risk adjustment to enable comparisons across different ICU groups and can be predictive of outcomes such as mortality. The measures in this study have also not been adjusted for the presence of comorbidities. As such, results provided should be interpreted with caution.

Data on ICU-specific admission diagnosis was not available for this study. Case Mix Groups (CMGs) were used to classify ICU patients into clinical groups. CMGs are based on the combination of diagnoses and interventions from a patient's overall hospital admission and not just on their time in the ICU. As a result, the conditions of patient groups reported on may not necessarily reflect their admitting diagnosis to the ICU. Furthermore, since CMGs are often

based on a single diagnosis or intervention, the volumes of patients reported within CMGs may not represent all patients within the ICU with that specific diagnosis as would be the case when multiple diagnoses or interventions are considered.

Process of care measures, such as ventilation and dialysis, were based on Canadian Classification of Health Interventions (CCI) codes. While the codes for ventilation allow for differentiation between short-term and long-term ventilation, information on the start and end times for these interventions are not mandatory in many cases. Therefore, process of care measures are based on patients' entire hospitalization and are not specific to just the ICU stay.

The results from the study do not distinguish between different types of general or specialized ICUs. Caution should be used in interpreting the findings as being representative of specific types of ICUs.

Data for chronically or critically ill patients who were admitted to an ICU prior to or during 2013–2014 but were not yet discharged, even by the end of 2014–2015, would not be captured in the data used for this study. However, this is applicable to only a small minority of hospitals and involves very low volumes.

The DAD does not contain information about the number of adult ICU beds in each acute care hospital. Therefore, the estimated number of beds provided in this study may be different from the true number of adult ICU beds available.

# Coverage

This study included data from all acute care hospitals in Canada, outside of Quebec. Due to differences in reporting and the use of the DAD, Quebec data was not available for inclusion in the study. Quebec's hospital data is reported to CIHI's Hospital Morbidity Database.

Unless it was applicable or provided context, an admission to a step-down unit (SDU) was excluded. However, the study includes admissions to provincially/territorially defined units (PTDUs). The way jurisdictions use and report SDU and PTDU data to CIHI varies. PTDUs are reported mainly by Nova Scotia, New Brunswick and Manitoba, while SDUs may be optional to report, as is the case for Alberta. The variation in use and reporting of these units may affect applicable results and findings from this study. In New Brunswick, PTDU refers to concentrated care beds or units; hospitals must receive approval from the provincial clinical data quality coordinator before they can apply this terminology to their data. In Manitoba, this term refers to the Intermediate Care Nursery at the Winnipeg Health Sciences Centre and the Winnipeg Children's Hospital. However, PTDUs in Manitoba were excluded from the study due to the age of their patients.

# Appendix B: Text alternative for figures

**Figure 2** Adult ICU beds per 100,000 population, adult ICU beds per 10,000 hospitalizations, age-standardized hospitalization rate, by province, 2013–2014

| Province/territory | ICU beds per 100,000 population (age 18+) | ICU beds per 10,000 hospitalizations (age 18+) | Age-standardized hospitalization rate per 1,000 population (age 18+) |
|---|---|---|---|
| Newfoundland and Labrador | 21.8 | 20.4 | 103.8 |
| Prince Edward Island | 11.1 | 10.2 | 104.5 |
| Nova Scotia | 13.6 | 13.7 | 94.2 |
| New Brunswick | 20.2 | 16.6 | 114.0 |
| Ontario | 14.2 | 16.0 | 87.3 |
| Manitoba | 11.2 | 10.5 | 105.0 |
| Saskatchewan | 11.2 | 8.6 | 126.7 |
| Alberta | 9.7 | 9.8 | 106.1 |
| British Columbia | 10.5 | 10.5 | 96.0 |

## Figure 6 Hospital admission category for adult medical or surgical ICU patients by province, 2013–2014

| | Urgent medical | Urgent surgical | Elective medical | Elective surgical |
|---|---|---|---|---|
| Newfoundland and Labrador | 57% | 27% | 1% | 15% |
| Prince Edward Island | 64% | 23% | 5% | 8% |
| Nova Scotia | 57% | 27% | 4% | 11% |
| New Brunswick | 56% | 31% | 3% | 9% |
| Ontario | 52% | 28% | 2% | 18% |
| Manitoba | 56% | 30% | 2% | 12% |
| Saskatchewan | 53% | 34% | 1% | 12% |
| Alberta | 44% | 31% | 2% | 23% |
| British Columbia | 50% | 31% | 2% | 17% |
| Total | **51%** | **29%** | **2%** | **17%** |

## Figure 7 Variation in rate of invasive ventilation (short and long term) among ICU patients, by province, 2013–2014

| | Long-term invasive | Short-term invasive |
|---|---|---|
| Newfoundland and Labrador | 7% | 18% |
| Prince Edward Island | 7% | 16% |
| Nova Scotia | 8% | 22% |
| New Brunswick | 4% | 14% |
| Ontario | 9% | 25% |
| Manitoba | 11% | 34% |
| Saskatchewan | 8% | 27% |
| Alberta | 8% | 23% |
| British Columbia | 9% | 26% |
| Total | **8%** | **24%** |

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