

## Original Article

# Characterizing Physician-Staffing Models in the Care of Postoperative Cardiac Surgical Patients in Canada

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### ABSTRACT

**Background:** Current intensive care unit physician-staffing (IPS) models for postoperative cardiac surgery have not been previously investigated in Canada. The purpose of this study was to determine current IPS models at 2 time points and describe the evolution of Canadian cardiac surgery IPS models.

**Methods:** A survey of 32 Canadian cardiovascular intensive care units (CVICUs) was undertaken in 2012 and 2017 to determine IPS models of care during “daytime” and “after-hours” in each unit. Data were collected regarding surgical volume, base specialties, and style of IPS management (“open”; “semi-open”; “closed”). In addition, we collected the overnight experience level of the bedside healthcare provider for in-house intensive care units.

**Results:** Survey responses were received from 27 of 32 CVICUs (87%). As of 2017, the style of 1 (4%) was open, 7 (26%) were semi-open, and 19 (70%) were closed in their unit IPS strategy. Base specialties of

### RÉSUMÉ

**Introduction :** Les modèles actuels de dotation en médecins aux soins intensifs (DMSI) postopératoires de chirurgie cardiaque n'ont pas fait l'objet d'études antérieures au Canada. L'objectif de la présente étude était de déterminer les modèles actuels de DMSI à deux points temporels et de décrire l'évolution des modèles de DMSI de chirurgie cardiaque au Canada.

**Méthodes :** Nous avons entrepris une enquête auprès de 32 unités de soins intensifs cardiovasculaires du Canada (USICC) en 2012 et en 2017 pour déterminer les modèles de soins DMSI « pendant la journée » et « après les heures normales » dans chaque unité. Nous avons collecté les données relatives au volume d'interventions chirurgicales, aux spécialités de base et au style de gestion de la DMSI (« ouvert », « semi-ouvert », « fermé »). De plus, nous avons collecté les données sur le niveau d'expérience de nuit des prestataires de soins au chevet des patients des unités intégrées de soins intensifs.

The cardiovascular intensive care unit (CVICU) has experienced many changes since its origins in the 1960s.<sup>1</sup> Evolution and innovation in the perioperative care of the cardiac

surgery patient has been reported to significantly contribute to improved postoperative outcomes in an aging and increasingly comorbid contemporary patient population.<sup>2-4</sup> However, with the growing complexity in cardiac surgery case mix and the rapid growth of acute and durable mechanical circulatory support programs, a need for a multidisciplinary approach and specific expertise in critical care to further improve outcomes has been established.<sup>1,5-7</sup> Despite this evolution in patient and team changes, there remains ongoing debate as to what should constitute the “ideal” CVICU physician-staffing model.

Intensive care physician staffing (IPS) has been reported to be an important determinant of patient outcomes

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See page 1370 for disclosure information.

CVICU physicians varied. A medical doctor provided after-hours coverage in 81% of CVICUs. Senior residents (37%) or critical care certified attending staff (25%) typically provided after-hours coverage for in-house CVICUs. Linked Canadian Institute for Health Information data did not indicate a difference among CVICU models in mortality or rehospitalization for coronary artery bypass graft or valve procedures.

**Conclusions:** Considerable heterogeneity is demonstrated in CVICU staffing patterns. No consensus was identified regarding the appropriate level of training for “after-hours” coverage. In-house overnight physician staffing in CVICUs varies widely. Finally, semi-open and closed style models did not demonstrate differences compared to Canadian Institute for Health Information data. Variability among CVICUs does exist; however, benefits of one model over another have not been identified.

following intensive care unit (ICU) admission.<sup>1,8-15</sup> Previous analyses have demonstrated reduced mortality rates and shorter durations of ICU stay with the involvement of a dedicated intensive care medical specialist (ie, an intensivist) and a multidisciplinary team.<sup>10,12,16,17</sup> It was also found that a closed, high-intensity staffing model, defined as “mandatory intensivist consultation or closed ICU (all care directed by intensivist),”<sup>12</sup> was associated with reduced ICU and hospital mortality.<sup>8,9</sup> Indeed, a “closed” format has been suggested as the favoured IPS model and has driven policy-making decisions regarding ICU staffing.<sup>1,8-15,18,19</sup> However, an open vs closed style of physician staffing remains controversial.<sup>20</sup> In addition to demonstrating that patient mortality and length of stay (LOS) benefited from open rather than closed style units, critics of the open model claimed that past studies purporting the benefits of an open model carried inherent design limitations in statistical methodology, their small sample sizes, and ICU specificity (medical vs surgical ICUs).<sup>20</sup> However, the idea of a model that blends both the closed and open styles may satisfy the need for the collaborative teamwork necessary for complex ICU patients.<sup>21</sup> To date, no clear guidelines on the preferred kind of staffing model have been put forward by any of the North American cardiac or cardiothoracic societies; however, the Society of Critical Care Medicine and the American College of Critical Care Medicine have stated that the ideal ICU model should have 24-hour dedicated intensive care physicians.<sup>22</sup>

The main purpose of this study was to characterize the current state of cardiac surgery IPS models across Canada. We hypothesized that significant variability exists in the care of postoperative patients after cardiac surgical procedures. The secondary purpose of this study was to determine the evolution of IPS models in CVICU’s across Canada over the past 5 years.

**Résultats :** Nous avons reçu les réponses à l’enquête de 27 des 32 USICC (87 %). Depuis 2017, le style de 1 (4 %) USICC était ouvert, de 7 (26 %) était semi-ouvert et de 19 (70 %) était fermé dans leur stratégie de DMSI à l’unité. Les spécialités de base des médecins de l’USICC variaient. Un docteur en médecine offrait ses services après les heures normales dans 81 % des USICC. Les résidents chevronnés (37 %) ou les médecins titulaires agréés en soins aux patients en phase critique (25 %) offraient habituellement leurs services après les heures normales aux USICC intégrées. Les données liées de l’Institut canadien d’information sur la santé n’indiquaient pas de différence entre les modèles des USICC en ce qui a trait à la mortalité ou à la réhospitalisation en raison de pontages aortocoronariens ou d’interventions valvulaires.

**Conclusions :** Les modèles de dotation en personnel aux USICC démontrent une importante hétérogénéité. Aucun consensus n’a été établi quant au niveau approprié de formation pour les services offerts « après les heures normales ». Le personnel médical de nuit à l’interne des USICC varie grandement. Finalement, les modèles de styles semi-ouverts et fermés ne démontraient pas de différence par rapport aux données de l’Institut canadien d’information sur la santé. Une variabilité existe entre les USICC. Toutefois, les avantages d’un modèle par rapport à un autre n’ont pas été définis.

## Materials and Methods

### Survey development

A cross-sectional survey of Canadian CVICU directors was undertaken at 2 time points (2012 and 2017; survey provided in [Supplemental Appendix S1](#)). The study was approved by the University of Manitoba Research Ethics Board (H2016:380) and the St Boniface Hospital Research Review Committee (RRC/2016/1612). Questions were developed by an expert panel from the Canadian Cardiovascular Critical Care (CANCARE) Society. The survey ([Supplemental Appendix S1](#)) was refined over several rounds of discussion to include a total of 43 questions that addressed a variety of ICU characteristics including admission volumes, “open” vs “semi-open” vs “closed” IPS models, physician specialty and critical care certification, and differences between in-house “daytime” vs “after-hours” management. An “open” IPS model was defined as a unit in which each patient was managed by their attending cardiac surgeon with availability of consultation with a critical care specialist as needed.<sup>8,9,12</sup> A “semi-open” CVICU was defined as a unit in which a dedicated consultant (defined as an MD of any discipline whose primary responsibility is in the ICU and who is not concurrently working in the operating room or out-patient clinic) attended the ICU 5-7 days a week, but the cardiac surgeon was either the physician of record or shared care of the patient with the unit consultant. Finally, a “closed” model CVICU was defined as a unit in which a dedicated postoperative care unit consultant (defined as an attending-level MD) was designated as the patient’s primary physician. “After-hours” was defined as evenings/nights (with no predefined hour of the day) and weekends. The term “certified” physician was defined as an individual who had completed a formal critical care fellowship (pre- and post-institution of the Royal College of

Physicians and Surgeons of Canada (RCPSC) Critical Care Medicine examination in 2006) or were grandfathered in because they had a dedicated interest in ICU patient management and had received additional critical care training before the fellowship program was established.

### Survey administration

A list of all the CVICUs across Canada was obtained from the Canadian Society of Cardiac Surgeons (CSCS) and the Canadian Cardiovascular Critical Care (CANCARE) Society member lists. Phone numbers and e-mails were collected by looking up the facility online or were obtained from contacts. A total of 32 CVICUs were contacted based on best available information. Each CVICU director was invited to participate in an electronic survey using [www.SurveyMonkey.com](http://www.SurveyMonkey.com). Another e-mail was sent to those directors who did not respond within 2 weeks of the initial invitation. A phone call was placed after another 2 weeks had elapsed, to inquire if the survey had been received. An over-the-phone interview was conducted with those directors who wished to participate but could not fill out the survey online. The survey was first completed in 2012, and a follow-up survey was completed in 2017 to determine if any changes in IPS models had occurred over time. The most-recent responses were taken from each of the responding sites throughout survey administration.

### Data analysis

Survey responses were collected and tabulated on [www.SurveyMonkey.com](http://www.SurveyMonkey.com), and raw responses were exported to the Microsoft Excel software package. Summary statistics presented in tables and figures were generated in Microsoft Excel. Data were presented descriptively using means, medians, and percentages, as appropriate. A series of frequency graphs presented trends on base specialties of the physicians, the location and type of ICU, typical level of training for the personnel providing in-house and "after-hours" coverage, and extent of physician coverage. These factors were tabulated for the study cohort and grouped by geographic region.

The Canadian Institute for Health Information (CIHI) releases a publicly available annual Cardiac Care Quality Indicators Report. The available report from 2016 provided risk-adjusted cardiac surgical outcome rates aggregated by site (excluding Quebec) for a 3-year period spanning April 2012 to March 2015.<sup>23</sup> This reporting period was selected because it includes outcome data from between the 2 survey cycles. Physician-staffing characteristics obtained from the survey were linked with this publicly available outcome data to determine if sites with certain characteristics had higher or lower adjusted clinical outcome rates following coronary artery bypass grafting (CABG) or aortic valve replacement (AVR). Adjusted outcome rates for (i) 30-day mortality after CABG, (ii) 30-day mortality after isolated AVR, (iii) 30-day mortality after CABG + AVR, and (iv) 30-day hospital readmission after CABG were compared between sites reporting certain staffing characteristics using a Mann–Whitney test. This analysis was performed using SAS version 9.3 (SAS Institute Inc, Cary, NC).

## Results

Of the 32 Canadian cardiac surgical intensive care units surveyed, 23 (72%) responded in 2012, 26 (81.3%) responded in 2017, and 23 (71.9%) responded at both time points. One site's most recent response was in 2012; therefore, it was carried forward to 2017. Thus, a total of 27 responding CVICUs were included in the data analysis.

### ICU type

Details about the CVICU type and staffing model can be seen in [Table 1](#). In the majority of responding programs (70%), a dedicated CVICU provided the care. Among the 23 sites that responded in both 2012 and 2017, changes were noted in the style of the CVICU in 2 sites—one site in British Columbia went from being a dedicated CVICU to being a surgical ICU, and one site in Atlantic Canada switched from being a surgical ICU to being a dedicated CVICU.

### IPS model

The predominant staffing model identified was a "closed" unit in 70% of programs. Several sites ( $n = 7$ ) changed over the course of the 2012 to 2017 surveys. One site from British Columbia went from being an "open" to being a "semi-open" model. Additional sites from Ontario, British Columbia and Montreal changed from a "semi-open" model to a "closed" model ( $n = 3$ ). Conversely, sites from Ontario, the Prairies, and Atlantic Canada switched from a "closed" model to a "semi-open" model ( $n = 3$ ).

### ICU depictees

Across the 27 responding units in 2017, an average of 1014 cardiac procedures were performed yearly at each site, of which an average of 1003 (98.9%) required postoperative monitoring. Of the 27 units, 1 (4%) had an "open" unit type, 19 (70%) had a "closed" unit type, and 7 (26%) had a "semi-open" unit type ([Supplemental Table S1](#)). Disposition after discharge from post-surgery ICUs was also displayed ([Supplemental Table S2](#)), with the majority of centres reporting transfer to a dedicated postoperative ward.

### Base specialties and critical care medicine involvement

The base specialties (primary training) of intensive care physicians varied across the 27 units ([Fig. 1](#)). Specifically, these included anesthesia (25 of 27 units), general medicine (16 of 27 units), cardiac surgery (12 of 27 units), noncardiac surgery (6 of 27 units), and other (9 of 27 units), including emergency medicine, cardiology, internal medicine, critical care, general practice, and respirology ([Supplemental Table S3](#)). Survey data did indicate that 5 units specified anesthesia as the only base specialty. Of these 5 units, 4 identified as being closed, and 1 as being semi-open. Patients were managed or comanaged by one or more physicians certified in critical care medicine in 21 of the 27 responding units. Furthermore, one or more of these physicians, with identified base specialties, are present in all 27 units during daytime hours, with their time dedicated to just one ICU ([Supplemental Table S1](#)).

**Table 1. Physician staffing characteristics of Canadian cardiovascular intensive care units**

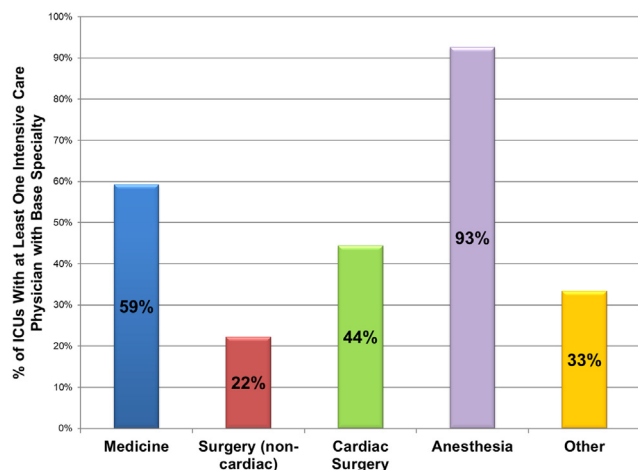
Survey response	Full cohort (N = 27)	British Columbia (n = 5)	Prairies (n = 4)	Ontario (n = 9)	Quebec (n = 6)	Atlantic Canada (n = 3)
<b>Intensive care physician staffing model</b>						
Closed	19 (70)	3 (60)	2 (50)	7 (78)	6 (100)	1 (33)
Semi-open	7 (26)	2 (40)	2 (50)	2 (22)	0 (0)	1 (33)
Open	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	1 (33)
<b>Intensive care unit type</b>						
Dedicated postoperative cardiac surgery ICU	19 (70)	4 (80)	3 (75)	7 (78)	2 (33)	3 (100)
Mixed ICU	6 (22)	0 (0)	1 (25)	1 (11)	4 (67)	0 (0)
General surgical ICU	2 (8)	1 (20)	0 (0)	1 (11)	0 (0)	0 (0)
<b>Most responsible physician</b>						
Intensivist	20 (74)	0 (0)	4 (100)	8 (89)	6 (100)	2 (67)
Cardiac surgeon	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	1 (33)
Cardiac anesthetist	5 (19)	4 (80)	0 (0)	1 (11)	0 (0)	0 (0)
Other	1 (4)	1 (20)	0 (0)	0 (0)	0 (0)	0 (0)
<b>Average daily attending physician coverage, h</b>						
0–12	21 (78)	5 (100)	2 (50)	6 (67)	5 (83)	3 (100)
13–24	6 (22)	0 (0)	2 (50)	3 (33)	1 (17)	0 (0)
<b>After-hours staffing</b>						
In-house physician coverage	22 (81)	2 (40)	4 (100)	9 (100)	5 (83)	2 (67)
No in-house physician coverage	5 (19)	3 (60)	0 (0)	0 (0)	1 (17)	1 (33)
<b>Training of managing physician</b>						
Certified in critical care medicine	20 (77)	0 (0)	4 (100)	8 (89)	6 (100)	2 (100)
Not certified in critical care medicine	6 (23)	5 (100)	0 (0)	1 (11)	0 (0)	0 (0)

Responses are expressed as n (%), with percentages calculated based on non-missing responses to respective question. ICU, intensive care unit.

### Level of training of in-house staff

The range of level of training for in-house coverage varied vastly among the units and included junior residents, clinical associates, and physician assistants, on up to the attending-physician/surgeon level.

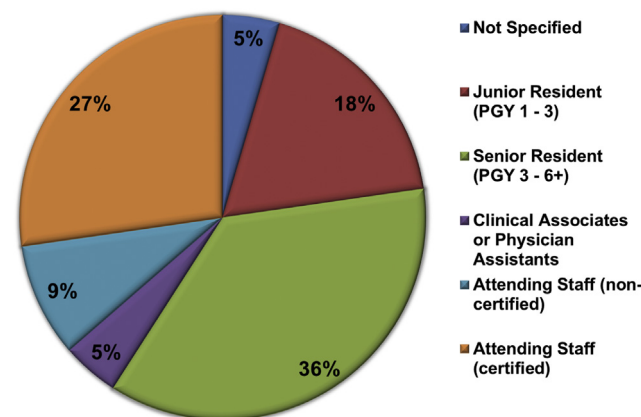
A total of 22 of 27 units (81%) provided responses to the survey questions about in-house “after-hours” coverage. The breakdown for these 22 sites is as follows: 1 (5%) not specified; 4 (18%) junior resident physicians; 8 (36%) senior resident physicians; 1 (5%) clinical associates/physician assistants; 2 (9%) attending staff (not certified); and 6 (27%) attending staff (certified; Fig. 2).



**Figure 1.** Percentage of base specialties of intensive care physicians represented in intensive care units (ICUs).

### Additional team management features

The majority of reporting CVICUs, 24 of 27 units (89%), involved a clinical pharmacist as a formal part of the ICU patient rounds. Within the team, the intensivist functions as the “most responsible physician (MRP)” and has responsibility for order writing and ongoing daily management (eg, cardiac management issues, ventilator issues) during “daytime” and “after-hours.” Additionally, residents were responsible for day-to-day care of patients in 74% of the CVICUs following the direction of more-senior physicians (ie, intensivists) on the unit. CVICU team members were also responsible for diagnostic assessments, such as



**Figure 2.** Typical level of training for the personnel providing the in-house “after-hours” coverage (ie, evenings/nights and weekends). PGY, postgraduate year.

echocardiography; these team members are presented in [Supplemental Table S4](#), along with CVICU access to echocardiography services.

### Impact of IPS models and postoperative outcomes

The most-recent physician-staffing characteristics obtained from the survey were linked with the 2016 CIHI data to determine if participating sites had higher or lower adjusted clinical outcome rates after CABG and AVR. Adjusted outcome rates for 30-day mortality and 30-day hospital readmission were compared. Sites with dedicated postoperative CVICUs appear to have a slightly lower adjusted 30-day AVR mortality (2.0% vs 3.2%;  $P = 0.09$ ) and 30-day CABG rehospitalization rates (9.1% vs 11.2%;  $P = 0.07$ ), compared to those for mixed/general surgical ICUs. Furthermore, sites with “in-house” physician coverage (indicated as “yes” for in-house physician coverage on the survey) during after-hours have slightly lower 30-day CABG rehospitalization rates (9.1% vs 11.6%;  $P = 0.09$ ), compared to those for sites with no in-house physician coverage (indicated as “no” for in-house physician coverage on the survey; [Table 2](#)).

### Discussion

To our knowledge, this is one of the first surveys seeking to describe the IPS models in Canadian cardiac surgery centres. The strengths of this study are the relatively high rate of

response (84.3%), the description of changes over time, and linkages with the CIHI.

The majority of reporting centres (96%) described either a “closed” or “semi-open” model of care within a dedicated CVICU. Contemporary cardiac surgery has allowed for patients with a greater number of comorbidities and chronic conditions to undergo cardiac surgery, creating at the same time more-vulnerable patients with higher acuity.<sup>24</sup> These changes brought forth a need to provide subspecialized, critical care training to cardiac surgery graduates. The first wave of graduates with a formal Royal College of Physicians and Surgeons of Canada (RCPSC) designation started clinical practice in 2006. Although general systems ICUs (ie, non-cardiac based ICUs) and CVICUs share basic similarities, such as the provision of 24-hour patient monitoring and a high nurse-to-patient ratio, important differences exist. In particular, cardiac surgery patients requiring ICU admission have been shown to have greater use of mechanical circulatory support therapies, extracorporeal membrane oxygenation, and continuous cardiac output/O<sub>2</sub>/CO<sub>2</sub> monitoring, as well as access to unique diagnostic equipment (eg, echocardiography).<sup>25,26</sup>

The few studies conducted to date on IPS in CVICUs have suggested that the “closed” style of unit, with an intensivist specializing in critical care responsible for the ICU care, is the ideal model.<sup>2,5,6,24,25</sup> This determination is in contrast to the concerns raised by Toeg et al. based on the theoretical conflict

**Table 2. Physician staffing characteristics compared to Canadian Institute for Health Information (CIHI) outcomes**

Survey response	CIHI adjusted outcome (N = 21)*			
	CABG 30- day mortality	AVR 30-day mortality	CABG + AVR 30-day mortality	CABG 30-day rehospitalization
<b>Intensive care physician staffing model</b>				
Closed	1.1 (0.9–2.0)	2.2 (2.0–2.8)	4.7 (3.9–6.2)	9.8 (8.5–11.4)
Semi-open	1.2 (1.0–1.9)	1.8 (1.4–2.7)	4.9 (4.1–5.6)	9.2 (8.7–9.8)
<i>P</i> value	0.81	0.34	0.66	0.72
<b>Intensive care unit type</b>				
Dedicated postoperative cardiac surgery ICU	1.2 (1.0–1.9)	2.0 (1.4–2.7)	4.7 (3.9–4.9)	9.1 (8.5–11.0)
Mixed ICU/general surgical ICU	1.6 (1.0–2.0)	3.2 (2.5–3.8)	5.7 (3.6–6.8)	11.2 (9.8–13.4)
<i>P</i> value	0.72	0.09	0.42	0.07
<b>Most responsible physician</b>				
Intensivist	1.8 (1.0–2.0)	2.2 (1.8–2.7)	4.7 (3.0–6.4)	9.4 (8.5–11.0)
Other	1.2 (0.9–1.2)	2.8 (1.4–3.6)	4.7 (4.1–4.9)	9.3 (8.8–11.8)
<i>P</i> value	0.37	0.65	0.65	0.77
<b>Average daily attending physician coverage, h</b>				
0–12	1.2 (1.0–1.9)	2.3 (1.5–2.8)	4.7 (4.0–6.0)	9.5 (8.7–11.6)
13–24	1.7 (0.9–2.0)	2.2 (1.8–2.8)	4.9 (2.7–4.9)	8.9 (7.1–10.3)
<i>P</i> value	0.90	0.84	0.62	0.36
<b>After-hours staffing</b>				
In-house physician coverage	1.7 (1.0–2.0)	2.2 (1.7–2.7)	4.7 (3.9–6.2)	9.1 (8.5–10.3)
No in-house physician coverage	1.1 (0.6–1.2)	3.2 (1.9–3.6)	4.8 (3.6–5.0)	11.6 (10.4–12.1)
<i>P</i> value	0.18	0.30	0.72	0.09
<b>Training of managing physician</b>				
Certified in critical care medicine	1.8 (1.0–2.0)	2.2 (1.8–2.7)	4.9 (3.0–6.4)	9.0 (8.1–11.0)
Not certified in critical care medicine	1.1 (0.9–1.2)	2.0 (1.4–3.6)	4.7 (4.4–4.9)	9.5 (9.2–11.4)
<i>P</i> value	0.23	0.84	0.68	0.36

AVR, aortic valve replacement; CABG, coronary artery bypass graft; ICU, intensive care unit.

CIHI outcomes are reported as adjusted events rates per 100 cases. Summary statistics are expressed as median (quartile 1–quartile 3); compared using Mann–Whitney test.

\*Adjusted outcome rates were reported by CIHI from 3-year cumulative data for cases between fiscal year 2012/2013 to 2014/2015. Outcomes were not reported for Quebec sites.

that could arise in a “closed” model when the surgeon and surgical trainee are excluded from participation in the ICU care.<sup>27</sup> Increasingly complex patients require physicians who possess multifaceted skills. We suggest that improvement in CVICU management could be expected if cardiac surgical trainees are given the opportunity to be trained in both intraoperative and perioperative settings.<sup>2,27</sup> In support of this possibility, a call to create credentialing and recertification procedures (for cardiac critical care surgeons) modelled on those in other specialties was made in response to evolving CVICUs.<sup>28</sup>

This study also demonstrated that there is significant heterogeneity in the reported base specialties of intensive care physicians working in the CVICU. The more common ones were anaesthesia (91%) and medicine (57%), with cardiac surgery being involved in less than half (48%) of reporting centres. This finding may indicate that while CVICU care may be specialized, these skills can be acquired by a broad range of physicians, with appropriate training and time allocation to a dedicated CVICU.

In addition, some form of in-house “after-hours” coverage, meaning evenings/nights and weekends, was present in the majority of reporting centres. The typical training level for personnel covering these shifts was variable, with slightly over one-third of residents being senior (postgraduate year 3-6+). Furthermore, only 25% of all personnel were classified as “certified,” and 13% were classified as “uncertified.” Taken together, these data suggest that “after-hours” coverage for many Canadian CVICUs was provided by junior trainees, with some CVICUs having no in-house physician coverage despite heightened patient acuity.

Linkage of survey data to CIHI data indicated that sites with dedicated postoperative CVICUs, compared to mixed/general surgical ICUs, trended toward differences in adjusted 30-day AVR mortality (2.0% vs 3.2%, respectively;  $P = 0.09$ ) and 30-day CABG rehospitalization rates (9.1% vs 11.2%, respectively;  $P = 0.07$ ). However, these differences were not statistically different, and they are in contrast to findings from previous research.<sup>5,6,8,9,12,24-26</sup> An important point to note is that CIHI data included only CABG and valve surgeries and not combined or concomitant more complex surgery procedures (eg, aortic aneurysm or dissection). Indeed, the lack of an association with the reported IPS model and CIHI data (2016) suggests that IPS and its effect on outcomes likely involves a complex relationship that is beyond the scope of the present study or unable to be captured in its design.

Our results have demonstrated a mosaic of differences in CVICUs in Canada. We acknowledge that, although these are the most recent staffing models, our approach has limitations, as these models do change with time, and our approach could not assess a number of physician-specific factors, such as physician, surgeon, and team engagement in each model. Further, we did not specifically inquire about bedside nurse-to-patient ratios for this survey. As the concept of phase-of-care mortality analysis is more often used to determine root cause of death, and as use of the occurrence of failure-to-rescue becomes increasingly recognized as a quality metric of cardiac surgical programs, it is notable that programs with lower operative mortality are associated with higher ability to rescue patients from complications.<sup>29,30</sup> Furthermore, recent

data suggest that the use of a dedicated 24/7 cardiac ICU care team<sup>31</sup> and quality improvement initiatives<sup>32</sup> may result in incremental improvement in outcomes over time. It is apparent, however, based on the data collected in this survey along with the available CIHI data, that there is no clear consensus regarding the ideal CVICU structure or staffing model. Thus, we believe that our study highlights the need for a more detailed look into the CVICUs in Canada, to better understand staffing factors that could affect outcomes beyond this initial investigation. For example, the level of motivation for change of the physician model in the centres reporting physician-staffing model modification is unknown. Future studies should investigate drivers of change, such as reasons relating to clinician/patient care, and alteration in human or other resource allocation. Furthermore, perioperative team and patient/caregiver perspectives should be investigated. Alternatively, it could be reasoned that different levels of “intensity” of physician-staffing models produce similar results, thereby indicating that outcomes can be impacted by addressing the physician ICU model alone, without examination of the culture of the unit. Moreover, although mortality (including failure to rescue) is an important metric for the “success” of a unit, patient-centred outcomes must also be considered. Development of research hypotheses to understand these important factors should be undertaken.

## Conclusion

The considerable heterogeneity in CVICU staffing patterns across Canada was demonstrated in this survey, including the level of training for personnel for “after-hours” coverage, which could have important implications for patient care. The effect of variable overnight staffing and the long-term impact of IPS experience require further evaluation with respect to patient outcomes.

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### Supplementary Material

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