




The state of adoption of anesthesia information management systems in Canadian academic anesthesia departments: a survey

État de l'adoption des systèmes de dossiers informatiques en anesthésie dans les départements universitaires d'anesthésie canadiens : une enquête

Pooya Kazemi, MD · Francis Lau, PhD · Allan F. Simpao, MD, MBI ·
R. J. Williams, MA · Clyde Matava, MBChB, MMed, MHSC 

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Abstract

Purpose Anesthesia information management systems (AIMS) are gradually replacing paper documentation of anesthesia care. This study sought to determine the current status of AIMS adoption and the level of health informatics expertise in Canadian academic anesthesia departments.

Methods Department heads or their designates of Canadian academic anesthesia departments were invited by e-mail to complete an online survey between September 2019 and February 2020. The survey elicited information on current AIMS or future plans for an AIMS installation, the number of department members dedicated to clinical informatics issues, the gross level of health informatics expertise at each department, perceived advantages of

AIMS, and perceived disadvantages of and barriers to implementation of AIMS.

Results Of the 64 departments invited to participate, 63 (98.4%) completed the survey. Only 21 (33.3%) of the departments had AIMS. Of the 42 departments still charting on paper, 23 (54.8%) reported planning to install an AIMS within the next five years. Forty-six departments (73%) had at least one anesthesiologist tasked with dealing with AIMS or electronic health record issues. Most reported having no department members with extensive knowledge or formal training in health informatics. The top three perceived barriers and disadvantages to an AIMS installation were its initial cost, lack of funding, and a lack of technical support dedicated specifically to AIMS. The top three advantages departments wished to prioritize with AIMS were accurate clinical documentation, better data for quality improvement initiatives, and better data for research.

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P. Kazemi, MD
South Island Department of Anesthesia, Victoria, BC, Canada

Department of Anesthesiology, Pharmacology and Therapeutics,
University of British Columbia, Vancouver, BC, Canada

School of Health Information Science, University of Victoria,
Victoria, BC, Canada

F. Lau, PhD
Department of Anesthesiology, Pharmacology and Therapeutics,
University of British Columbia, Vancouver, BC, Canada

A. F. Simpao, MD, MBI
Department of Anesthesiology and Critical Care, Perelman
School of Medicine at the University of Pennsylvania and
Children's Hospital of Philadelphia, Philadelphia, PA, USA

R. J. Williams, MA
Department of Anesthesia and Pain Medicine, The Hospital for
Sick Children, 555 University Avenue, Toronto, ON M5G 1X8,
Canada

C. Matava, MBChB, MMed, MHSC (✉)
Department of Anesthesia and Pain Medicine, The Hospital for
Sick Children, 555 University Avenue, Toronto, ON M5G 1X8,
Canada
e-mail: Clyde.matava@sickkids.ca

Department of Anesthesiology and Pain Medicine, Faculty of
Medicine, University of Toronto, Toronto, ON, Canada

Conclusions A majority of Canadian academic anesthesia departments are still using paper records, but this trend is expected to reverse in the next five years as more departments install an AIMS. Health informatics expertise is lacking in most of the departments, with a minority planning to support the training of future anesthesia informaticians.

Résumé

Objectif Les systèmes de gestion de l'information en anesthésie (SGIA) remplacent progressivement la documentation sur papier des soins anesthésiques. Cette étude a tenté de déterminer l'état actuel de l'adoption des SGIA et le niveau d'expertise en informatique de la santé dans les départements universitaires d'anesthésie canadiens.

Méthode Les chefs de département ou des responsables désignés des départements universitaires d'anesthésie canadiens ont été invités par courriel à remplir un sondage électronique entre les mois de septembre 2019 et février 2020. L'enquête a permis d'obtenir de l'information sur les SGIA actuels ou les plans futurs d'implantation d'un SGIA, le nombre de membres du département en charge des questions d'informatique clinique, le niveau brut d'expertise en informatique de la santé dans chaque département, les avantages perçus des SGIA, et les inconvénients perçus ainsi que les obstacles à la mise en œuvre des SGIA.

Résultats Sur les 64 départements invités à participer, 63 (98,4 %) ont rempli le sondage. Seuls 21 (33,3 %) départements disposaient d'un SGIA. Sur les 42 départements utilisant encore des dossiers papier, 23 (54,8 %) ont déclaré avoir l'intention d'installer un SGIA au cours des cinq prochaines années. Quarante-six départements (73 %) comptaient au moins un anesthésiologiste chargé de gérer les problèmes liés au SGIA ou aux dossiers médicaux électroniques. La plupart des départements ont déclaré ne pas compter, parmi leurs membres, de personne possédant des connaissances approfondies ou une formation officielle en informatique de la santé. Les trois principaux obstacles et inconvénients perçus à la mise en œuvre d'un SGIA étaient son coût initial, le manque de financement et un manque de soutien technique dédié spécifiquement aux SGIA. Les trois principaux avantages que les départements souhaitaient prioriser avec un SGIA étaient une documentation clinique exacte, de meilleures données pour les initiatives d'amélioration de la qualité et de meilleures données pour la recherche.

Conclusion La majorité des départements universitaires d'anesthésie canadiens utilisent toujours des dossiers papier, mais cette tendance devrait s'inverser au cours des cinq prochaines années, au fur et à mesure qu'un plus

grand nombre de départements installeront des SGIA. L'expertise en informatique de la santé fait défaut dans la plupart des départements, et une minorité des départements a l'intention de soutenir la formation des futurs informaticiens en anesthésie.

Keywords health information management · anesthesia information management systems · anesthesia · informatics

Anesthesia information management systems (AIMS) are gradually replacing paper documentation of anesthetics across Canada. These AIMS are specialized electronic documentation systems used by anesthesia providers to automatically and reliably collect, store, and present perioperative patient data.¹ In contrast, electronic health records (EHRs) are digital records of the patient that include their entire hospital encounter and do not necessarily incorporate specific AIMS. Modern AIMS were initially designed for intraoperative record keeping, but their functionality has gradually expanded in scope to include the entire perioperative period, including non-operating room environments such as labour and delivery floors, as well as post-surgical wards where they are used for documentation of acute pain management.²

In the United States (U.S.), the interest in AIMS spiked in 2001 when the Anesthesia Patient Safety Foundation recommended the use of such systems to improve patient safety.³ Currently, there are two types of AIMS: enterprise-wide systems and standalone systems, with each offering varying degrees of integration with the patient's EHR.^{2,3} Early AIMS were primarily standalone systems that functioned in isolation and were not integrated with EHRs. Nevertheless, with the increasing adoption of EHRs, AIMS are interfacing with and integrating into clinical and billing software.⁴ The use of AIMS has been shown to improve patient safety, quality of care, documentation, operations management, cost containment and reimbursement, and clinical research.^{5,6} Parallel to the implementation and growth of AIMS and EHRs in the U.S. has been the growth of expertise in clinical informatics, and with it, the proliferation of clinical informaticians in the healthcare setting. Clinical informaticians are often clinicians with experience in the administration, oversight, and implementation of AIMS and EHRs or have undertaken professional training and certification. The involvement of anesthesia clinical informaticians in the implementation and operation of AIMS has been reported to optimize the use of these systems.^{7,8}

Recent advancements in AIMS now include the use of clinical decision support systems (CDS), electronic

systems designed to help with clinical decision-making, in which reminders, alerts, and guidelines are passively or actively presented.⁹ Recent reviews have found evidence to support the use of near real-time and real-time CDS in AIMS, especially in the areas of surgical antibiotic prophylaxis, documentation compliance, and postoperative nausea and vomiting.^{10–12} Despite documented benefits, several barriers have prevented the universal adoption of AIMS including cost, lack of technical support, inadequate integration with an existing EHR, medicolegal concerns regarding missing or outlier data, the inconveniences of rapid documentation and electronic data entry during short or emergency procedures, lack of clinician involvement during design and implementation, and resistance to changes in clinical workflow patterns.^{13–17} There is evidence that most of these barriers are either exaggerated or can be overcome by targeting areas such as perceived usefulness and ease of use.^{5,18}

A survey of American academic anesthesia departments showed that approximately 75% were using AIMS by 2014 and predicted that this would increase to 84% sometime between 2018 and 2020.¹⁹ No published reports exist regarding the use of AIMS or the level of health informatics expertise in Canadian academic anesthesia departments. The aim of this study was to determine the current use of AIMS, plans to implement AIMS, the level of health informatics expertise, and the perceived advantages and disadvantages of AIMS at Canadian academic anesthesia departments.

Methods

Approval for this study was obtained in May 2019 from the University of Victoria Human Research Ethics Board. A review of recent literature on AIMS was undertaken to identify advantages, disadvantages, and barriers to adopting AIMS. A cross-sectional survey using a structured, branched-logic questionnaire was designed using the online survey development software SurveyMonkey® (SVMK Inc., San Mateo, CA, USA). The initial survey draft underwent several revisions, with input from all four authors, to improve the clarity and validity of the content. The survey was tested by two anesthesiologists who are involved in informatics who provided feedback. The survey included questions regarding department name and location, current AIMS or future plans for an AIMS installation, the number of anesthesia department members dedicated to AIMS and/or EHR, the level of health informatics expertise among anesthesia departments, perceived advantages of AIMS, and disadvantages of and barriers to implementation of

AIMs (eAppendix in the Electronic Supplementary Material). Royal College of Physicians and Surgeons of Canada accredited Canadian anesthesia residency programs were identified online. The administrative assistants of these programs were contacted by e-mail and asked to identify the individual anesthesia departments/hospitals that were considered residency teaching sites. These anesthesia department heads or their designates were then sent e-mail invitations to complete the survey via SurveyMonkey. Responses were collected from September 2019 to February 2020. For departments not responding to the initial request, a follow-up e-mail was sent two weeks later and then re-sent, if necessary, every two weeks for a total of four e-mails. Subsequently, for departments that did not answer, individuals in those anesthesia departments were personally contacted by e-mail or phone. Departments responding with unclear, vague, or incompletely answered questionnaires were re-contacted to obtain adequate answers. Data collected was entered into Excel® (Microsoft, Redmont, WA, USA) for descriptive statistical analyses.

Results

Of the 64 Canadian academic anesthesia departments invited to participate, 63 (98.4%) departments (covering 74 hospital sites) completed the survey (Fig. 1A and Table 1). Only 21 of the 63 (33.3%) departments had an AIMS, while 42 of 63 (66.7%) were still using a paper anesthesia record (Table 1). Some departments provided anesthesia services to more than one hospital, representing 26/74 hospitals (35.1%) with AIMS, while 48 of 74 (64.9%) were still documenting on paper (Table 1).

Of the 21 departments that had AIMS (Table 2), 17 (81%) reported that their current AIMS was their first system. The specific AIMS systems are listed in Table 2. The vendor of the hospital's enterprise EHR was the same as the vendor for the AIMS in eight (38.1%) of these 21 departments (Table 2). Seven (33.3%) of the 21 departments reported having plans to replace their AIMS in the next five years. An additional four departments (19%), all in Alberta, reported having had a previous AIMS installation (Anesthesia Manager, Picis, Wakefield, MA, USA) which was being replaced at the time of the survey. In terms of extraction and use of AIMS data, 15 of the 21 (71.4%) departments had used data from their AIMS systems for research or quality improvement. Of the departments that had performed data analytics, 13 (86.7%) had used their AIMS for quality assurance and quality improvement projects, 12 (66.7%) for research projects, and eight (53.3%) for anesthesia practice reports.

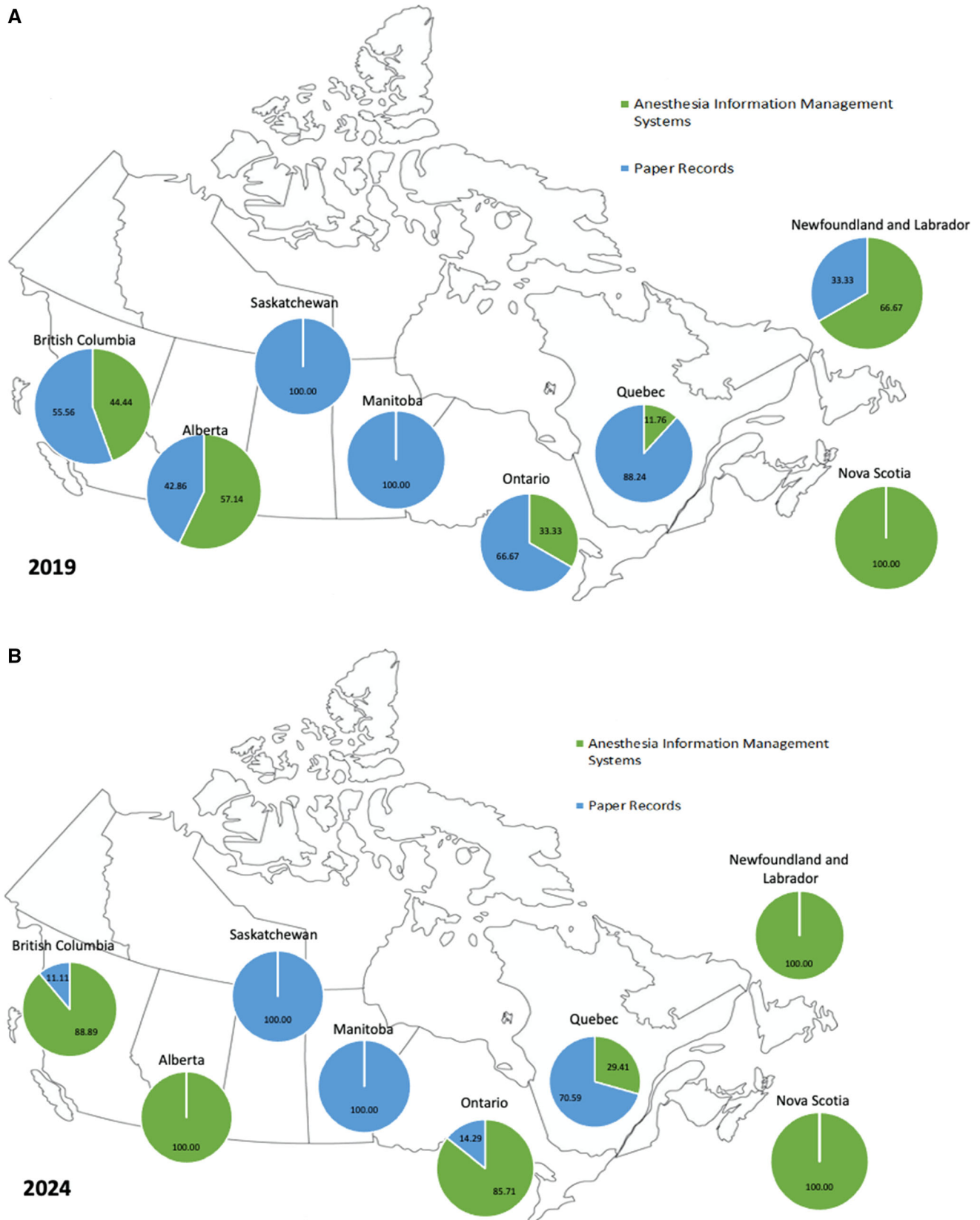


Fig. 1 The state of anesthesia information management systems at Canadian academic anesthesia departments implementation in each province in A) 2019; B) anticipated implementation in 2024

Table 1 Responding hospital characteristics

Hospital	Province	Department size	Institution type	Patient type	Charting system
Alberta Children's Hospital	Alberta	21–50		Pediatric	AIMS
FMC	Alberta	21–50	Academic tertiary		AIMS
Peter Lougheed Centre	Alberta	21–50	Academic tertiary		AIMS
Rockyview General Hospital	Alberta	21–50	Academic tertiary		AIMS
Royal Alexandra Hospital	Alberta	> 50	Academic tertiary		Paper
Stollery	Alberta	21–50	Academic tertiary	Pediatric	Paper
University of Alberta Hospital	Alberta	> 50	Academic tertiary		Paper
BC Children's Hospital	British Columbia	21–50	Academic tertiary	Pediatric	Paper
BC Women's Hospital	British Columbia	11–20	Academic tertiary	Adult	Paper
Kelowna General Hospital	British Columbia	21–50	Academic tertiary		Paper
Lions Gate Hospital	British Columbia	21–50	Academic community	Adult and pediatric	AIMS
Providence Health Care	British Columbia	21–50	Academic tertiary	Adult	AIMS
Royal Columbian Hospital	British Columbia	21–50	Academic tertiary		AIMS
Surrey Memorial Hospital	British Columbia	21–50	Academic tertiary	Adult and pediatric	AIMS
Vancouver General	British Columbia	> 50	Academic tertiary		Paper
Victoria General, Royal Jubilee Hospital	British Columbia	> 50	Academic tertiary	Adult and pediatric	Paper
Children's Hospital Winnipeg	Manitoba	11–20	Academic tertiary	Pediatric	Paper
Health Sciences Centre	Manitoba	> 50	Academic tertiary	Adult	Paper
St Boniface Hospital	Manitoba	> 50	Academic tertiary		Paper
Health Sciences Centre	Newfoundland and Labrador	21–50	Academic tertiary	Adult	AIMS
St Clare's Mercy Hospital	Newfoundland and Labrador	11–20	Academic tertiary		AIMS
Women's & Children's Health Janeway	Newfoundland and Labrador	2–10	Academic tertiary	Adult and pediatric	Paper
Halifax Infirmary, Victoria General Hospital	Nova Scotia	> 50	Academic tertiary	Adult	AIMS
IWK Health Centre	Nova Scotia	21–50	Academic tertiary	Adult and pediatric	AIMS
Children's & Women's					
Children's Hospital of Eastern Ontario	Ontario	21–50	Academic tertiary		AIMS
Hamilton Health Sciences	Ontario	> 50	Academic tertiary	Adult and pediatric	Paper
Kingston General Hospital	Ontario	21–50		Adult and pediatric	Paper
LHSC – Victoria Hospital, Children's Hospital	Ontario	> 50	Academic tertiary	Adult and pediatric	Paper
University Hospital, St. Joseph's					
McMaster Children's Hospital	Ontario	> 50	Academic tertiary	Adult and pediatric	Paper
Michael Garron Hospital	Ontario	11–20	Academic community	Adult and pediatric	Paper
Mount Sinai Hospital	Ontario	21–50	Academic tertiary		Paper
North Bay Regional Health Centre	Ontario	2–10	Academic community	Adult and pediatric	Paper

Table 1 continued

Hospital	Province	Department size	Institution type	Patient type	Charting system
North York General	Ontario	21–50	Academic community		AIMS
Sault Area Hospital	Ontario	2–10	Academic community	Adult and pediatric	Paper
St Joseph's Health Centre – Toronto	Ontario	11–20	Academic community		Paper
St Joseph's Healthcare – Hamilton	Ontario	21–50	Academic tertiary		AIMS
St. Michael's Hospital	Ontario	21–50	Academic tertiary	Adult	Paper
Sunnybrook Health Sciences Centre	Ontario	21–50	Academic tertiary		Paper
The Ottawa Hospital – University of Ottawa Heart Institute, Civic Hospital, Riverside, General Hospital	Ontario	> 50	Academic tertiary		AIMS
Thunder Bay Regional Health Sciences Centre	Ontario	11–20	Academic community	Adult and pediatric	Paper
Toronto Sick Kids	Ontario	21–50	Academic tertiary	Pediatric	AIMS
Trillium Health Partners	Ontario	> 50	Academic community	Adult and pediatric	Paper
UHN – Toronto General Hospital	Ontario	> 50	Academic tertiary		AIMS
UHN – Toronto Western Hospital	Ontario	> 50	Academic tertiary	Adult	AIMS
Women's College Hospital	Ontario	21–50	Academic community	Adult and pediatric	Paper
CHU de Québec	Quebec	> 50	Academic tertiary		Paper
CHU Ste-Justine	Quebec	21–50	Academic tertiary	Adult and pediatric	Paper
CHUM	Quebec	21–50	Academic tertiary		Paper
CIUSSSE-CHUS	Quebec	21–50	Academic tertiary & Academic community	Adult and pediatric	Paper
Hôpital Maisonneuve Rosemont – CIUSSS de l'est de l'île de Montréal	Quebec	21–50	Academic tertiary	Adult and pediatric	Paper
Hôpital St-Jérôme	Quebec	11–20	Academic community	Adult and pediatric	Paper
Hôtel Dieu d'Arthabaska	Quebec	2–10	Academic community		Paper
Hôtel Dieu de Lévis	Quebec	11–20	Academic community	Adult and pediatric	Paper
Hôtel-Dieu Sherbrooke	Quebec	11–20	Academic tertiary & Academic community	Adult and pediatric	Paper
IUCPQ	Quebec	11–20	Academic tertiary		Paper
Jewish General Hospital	Quebec	21–50	Academic tertiary		AIMS
Montreal Children's Hospital	Quebec	11–20	Academic tertiary	Pediatric	Paper
Montreal General Hospital	Quebec	11–20	Academic tertiary	Adult	Paper
Montreal Heart Institute	Quebec	11–20	Academic tertiary		AIMS
MUHC – Montreal Neurologic Hospital	Quebec	2–10	Academic tertiary		Paper
MUHC – Royal Victoria Hospital	Quebec	21–50	Academic tertiary	Adult	Paper
Sacré-Coeur	Quebec	11–20	Academic tertiary		Paper
Royal University Hospital, St Paul Hospital, Saskatoon City Hospital	Saskatchewan	> 50	Academic tertiary	Adult and pediatric	Paper

AIMS = anesthesia information management system

Of the 42 departments that were still documenting on paper, 23 (54.8%) reported plans for an AIMS installation in the next five years, while 19 (45.2%) reported that they

will continue with paper (Table 3). Ten of the 23 departments planning an AIMS installation did not yet know their future AIMS platform. The provisional future

Table 2 Anesthesia information management systems in current use at Canadian academic anesthesia departments

Hospital	Installation	Vendor	Same as electronic health record	First anesthesia information management system
Alberta Children's Hospital	Unknown	PICIS	No	Yes
Children's Hospital of Eastern Ontario	2019	Epic	Yes	Yes
FMC	2000	PICIS	No	Yes
Halifax Infirmary, Victoria General Hospital	2014	Drager	No	Yes
Health Sciences Centre	2015	GE Centricity	No	No
IWK Health Centre Children's & Women's	2014	Drager	No	No
Jewish General Hospital	2016	GE Centricity	No	Yes
Lions Gate Hospital	2018	Cerner	Yes	Yes
Montreal Heart Institute	2009	Phillips	No	Yes
North York General	2013	Cerner	No	Yes
Peter Lougheed Centre	Unknown	PICIS	No	Yes
Providence Health Care	2019	Cerner	Yes	Yes
Rockyview General Hospital	Unknown	PICIS	Yes	Yes
Royal Columbian Hospital	2014	GE Centricity	No	Yes
St Clare's Mercy Hospital	2016	GE Centricity	Yes	No
St Joseph's Healthcare Hamilton	2017	Epic	Yes	Yes
Surrey Memorial Hospital	2013	GE Centricity	No	Yes
The Ottawa Hospital – University of Ottawa Heart Institute, Civic Hospital, Riverside, General Hospital	2019	Epic	Yes	No
Toronto Sick Kids	2018	Epic	Yes	Yes
UHN – Toronto General Hospital	2010	Locally Developed	No	Yes
UHN – Toronto Western Hospital	2014	Locally Developed	No	Yes

vendors for the other departments were CernerTM (North Kansas City, MO, USA), EpicTM (Verona, WI), GETM (Chicago, IL, USA), and iMDsoftTM (Needham, MA, USA) (Table 3). Thus, for the known AIMS vendors of current and future installations, the top three AIMS by 2024 will be EpicTM, CernerTM, and GETM. By the year 2024, academic departments of anesthesia in all Canadian provinces are anticipated to have an AIMS system except for Saskatchewan and Manitoba (Fig. 1B)

Of the 63 departments, 46 (73%), had at least one anesthesiologist tasked with dealing with AIMS or EHR issues, while 17 (27%) reported no dedicated personnel (Fig. 2A). The number of anesthesiologists dedicated to AIMS or EHR reported by each department was one for 16 (25.4%) departments, two for 14 (22.2%), three for six (9.5%), four for four (6.3%), and five to ten for six (9.5%) departments. Nevertheless, when respondents were asked to identify the number of anesthesiologists in their

department who had extensive anesthesia informatics experience and had completed or were undergoing formal training (e.g., MSc, PhD, clinical fellowship, or board certification) in health informatics, there were none in 44 (69.8%) departments, one in 11 (17.5%) departments, two in 6 (9.5%) departments, three in one (1.6%) department, and four in one (1.6%) department (Fig. 2B). Eleven (17.5%) departments planned on identifying and supporting anesthesiologists to undergo formal training in health informatics; 25/63 (39.7%) of the departments had no plans for such support, and 27 (42.9%) of the departments were unsure (Fig. 2C).

The top five perceived barriers and disadvantages to an AIMS installation were: initial cost and lack of funding, lack of IT support dedicated specifically to AIMS, resistance from anesthesiologists, lack of a system that integrates with the institution's EHR, and lack of support from hospital administration (Table 4). The top three

Table 3 Planned future anesthesia management information systems

Hospital	Install AIMS within 5 years	Year of expected installation	Vendor	Same as hospital's electronic health record
Alberta Children's Hospital	Yes	2020	Epic	Yes
FMC	Yes	2020	Epic	Yes
Peter Lougheed Centre	Yes	2020	Epic	
Rockyview General Hospital	Yes	2021	Epic	Yes
Royal Alexandra Hospital	Yes	2020	Epic	Yes
Stollery	Yes	2019	Epic	Yes
University of Alberta Hospital	Yes	2019	Epic	Yes
BC Children's Hospital	Yes	2021	Cerner	Yes
BC Women's Hospital	Yes	2020	Cerner	Yes
Kelowna General Hospital	No			
Lions Gate Hospital	No			
Providence Health Care	No			
Royal Columbian Hospital	No			
Surrey Memorial Hospital	No			
Vancouver General	Yes	2020	Cerner	Yes
Victoria General, Royal Jubilee Hospitals	Yes	2021–2022	Cerner	Yes
Children's Hospital Winnipeg	No			
Health Sciences Centre	No			
St Boniface Hospital	No			
Health Sciences Centre	No			
St Clare's Mercy Hospital	No			
Women's & Children's Health Janeway	Yes	2020	GE Centricity	No
Halifax Infirmary, Victoria General Hospital	Yes	Unknown	Unknown	Yes
IWK Health Centre Children's & Women's	Yes	Unknown	Unknown	Yes
Children's Hospital of Eastern Ontario	No			
Hamilton Health Sciences	Yes	2020–2021	Unknown	Yes
Kingston General Hospital	Yes	2022	Unknown	Yes
LHSC – Victoria Hospital, Children's Hospital, University Hospital, St. Joseph's	Yes	2020	Cerner	Yes
McMaster Children's Hospital	Yes	2022	Unknown	Yes
Michael Garron Hospital	Yes	2023	Unknown	Yes
Mount Sinai Hospital	Yes	2020	Cerner	Yes
North Bay Regional Health Centre	No			
North York General	No			
Sault Area Hospital	Yes	2021	Unknown	No
St Joseph's Health Centre – Toronto	No			
St Joseph's Healthcare Hamilton	No			
St. Michael's Hospital	Yes	2022	Unknown	No
Sunnybrook Health Sciences Centre	Yes	2020	Unknown	No
The Ottawa Hospital – University of Ottawa Heart Institute, Civic Hospital, Riverside, General Hospital	No			
Thunder Bay Regional Health Science Centre	No			
Toronto Sick Kids	No			
Trillium Health Partners	Yes	2020	Epic	Yes
UHN – Toronto General Hospital	Yes	2022	Unknown	Yes
UHN – Toronto Western Hospital	No			
Women's College Hospital	Yes	2020	Epic	Yes

Table 3 continued

Hospital	Install AIMS within 5 years	Year of expected installation	Vendor	Same as hospital's electronic health record
CHU de Québec	Yes	2023	Unknown	No
CHU Ste-Justine	Yes	2021	iMDsoft	Yes
CHUM	No			
CIUSSSE-CHUS	No			
Hôpital Maisonneuve Rosemont - CIUSSS de l'est de l'île de Montréal	No			
Hôpital St-Jérôme	Yes	2022	Unknown	No
Hôtel Dieu d'Arthabaska	No			
Hôtel Dieu de Lévis	No			
Hôtel-Dieu Sherbrooke	No			
IUCPQ	No			
Jewish General Hospital	No			
Montreal Children's Hospital	No			
Montreal General Hospital	No			
Montreal Heart Institute	No			
MUHC – Montreal Neurological Hospital	No			
MUHC – Royal Victoria Hospital	Yes	2022–2023	Unknown	No
Sacré-Coeur	No			
Royal University Hospital, St Paul Hospital, Saskatoon City Hospital	No			

AIMS = anesthesia information management systems

advantages that departments indicated they wanted to prioritize with their current or future AIMS were to allow more accurate clinical documentation, improve data for quality improvement, and improve data for research (Table 4).

Discussion

Our study shows that while the majority (66.7%) of the anesthesia departments surveyed are still using a paper anesthesia record, these are in the process of being replaced by AIMS. More than half of these departments expect to have an AIMS installed in the next five years. It is expected that by the end of 2024, the majority (68.8%) of the anesthesia departments surveyed will have an AIMS. Given the potential benefits of an AIMS, there is some urgency for paper-based departments with no plans for AIMS installations to encourage their hospitals and provincial health leadership to strongly consider installing these systems. This study should provide some context for such appeals (Table 5).

Our study also shows that AIMS adoption in Canadian academic anesthesia departments is more than ten years behind their U.S. counterparts, who had a 75% adoption rate in 2014.¹⁹ This finding is not surprising, given that Canada significantly lags the U.S. in overall EHR adoption in both acute and primary care settings.^{20,21} The relatively low adoption of AIMS in Canada compared with the U.S. may be explained in part by the differences in funding sources, business models, and advocacy for AIMS systems by professional associations.¹⁹ In the U.S., the support for AIMS by the Anesthesia Patient Safety Foundation in 2001 provided an impetus to adopt AIMS and other health information technology (HIT); this was further enhanced by the Economic and Clinical Health Act (2009) that provided remunerations to hospitals that adopted EHR systems including AIMS.³ In contrast, in Canada, there is no national strategy enabling or supporting the transition to EHRs or AIMS systems.

In terms of health informatics expertise, the majority (69.8%) of the anesthesia departments surveyed reported having no department members with extensive informatics experience or formal health informatics education. There also appeared to be no urgency to train future anesthesia

Fig. 2 The state of anesthesiologist informaticians involved in anesthesia information management systems (AIMS). A) The number of anesthesiologists dedicated to supporting AIMS in each department; B) The number of anesthesiologists in their department who had extensive anesthesia informatics experience, had completed or were undergoing formal training (e.g., MSc, PhD, clinical fellowship, or board certification) in health informatics; C) Departments with plans to train anesthesiologists as informaticians

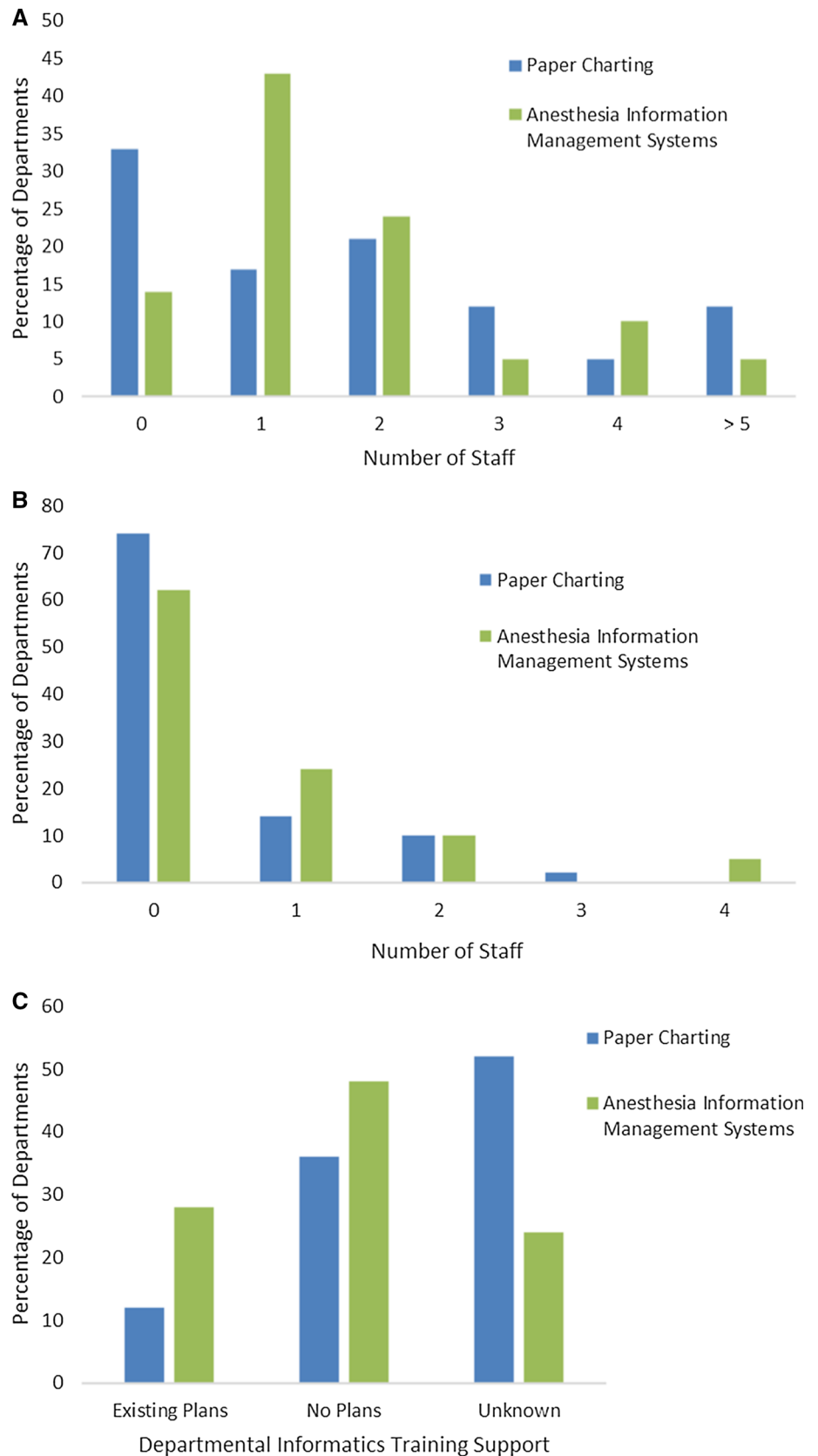


Table 4 Perceived barriers and disadvantages to anesthesia information management systems (AIMS) as reported by respondents using AIMS vs paper

Perceived barrier and/or disadvantage*†	Respondents using AIMS	Respondents using paper	Total
Initial cost and lack of funding	13 (61.9)	31 (73.8)	44 (69.8)
Lack of IT support dedicated specifically to AIMS	15 (71.4)	15 (35.7)	30 (47.6)
Resistance from anesthesiologists	8 (38.1)	17 (40.5)	25 (39.7)
Lack of system that integrates with institution's EMR	6 (28.6)	18 (42.9)	24 (38.1)
Lack of support from hospital administration	4 (19.0)	19 (45.2)	23 (36.5)
Lack of expertise/champion among anesthesia colleagues	6 (28.6)	15 (35.7)	21 (33.3)
Less efficient workflow	7 (33.3)	14 (33.3)	21 (33.3)
Ongoing IT costs	9 (42.9)	11 (26.2)	20 (31.7)
Fear of inaccurate records, legal implications	6 (28.6)	14 (33.3)	20 (31.7)
Competition for funding from other IT projects	8 (38.1)	4 (9.5)	12 (19.0)
Downtime that compromises patient safety	6 (28.6)	5 (11.9)	11 (17.5)
Unable to extract data for QI and research	5 (23.8)	3 (7.1)	8 (12.7)
Inadequate return on investment	3 (14.3)	4 (9.5)	7 (11.1)
No barrier/disadvantages over paper record	3 (14.3)	4 (9.5)	7 (11.1)

* Respondents asked to select ALL that apply

† Data are depicted as n (%) of responding departments where AIMS = 21, paper = 42, total = 63

EMR = electronic medical record; IT = information technology; QI = quality improvement

Table 5 Perceived advantages to anesthesia information management systems (AIMS) as reported by respondents using AIMS vs paper

Item *†	Respondents using AIMS	Respondents using paper	Total
Accurate clinical documentation	15 (71.4)	34 (81.0)	49 (77.8)
Better data for quality improvement	13 (61.9)	35 (83.3)	48 (76.2)
Better data for research	9 (42.9)	19 (45.2)	28 (44.4)
Improved patient safety	11 (52.4)	16 (38.1)	27 (42.9)
Improved efficiency	5 (23.8)	8 (19.0)	13 (20.6)
Reduced workload	5 (23.8)	7 (16.7)	12 (19.0)
Improved regulatory compliance	1 (4.8)	4 (9.5)	5 (7.9)
Easier tracking of supplies	1 (4.8)	3 (7.1)	4 (6.3)
Increased capture of billings	3 (14.3)	0 (0.0)	3 (4.8)

* Respondents asked to select ALL that apply

† Data are depicted as n (%) of responding departments where AIMS = 21, paper = 42, total = 63

informaticians, with 82.5% of the departments stating that they either did not plan or were unsure whether they wanted to identify and support department members to undergo formal health informatics training. Given that digital technologies and artificial intelligence may profoundly transform the practice of medicine, Canadian anesthesia departments and the national organizations the Canadian Anesthesiologists Society and the Canadian Pediatric Anesthesia Society could play a role in encouraging local and national development in anesthesia health informatics expertise.²² Without such expertise,

anesthesia departments may struggle to adjust to digital medicine and fail to realize the full potential of AIMS and other HITs available to them. A recent editorial in the *British Medical Journal*, asserted that “literacy in informatics should be a formal requirement of all medical education” if health professionals are to realize the full benefit of data and digital healthcare tools.²³

In the U.S., the American Board of Preventive Medicine offers clinical informatics as a subspecialty board certification. As of 2016, of the over 53,000 board-certified anesthesiologists in the U.S., only 50 had

additional board certification in clinical informatics, representing just 0.1% of that group. These numbers are likely to grow, and Canadian medical education leaders should consider creating a similar home-grown program to educate future Canadian physician informaticians. Although clinical informatics board certification programs do not exist in Canada, Digital Health Canada, a not-for-profit professional association focused on HIT, offers certification in healthcare information and management systems.²⁴ Other Canadian HIT resources include Canada Health Infoway and the Canadian chapters of Health Information and Management Systems Society.^{25,26}

While many of the respondents agreed that initial implementation costs could be significant barriers and disadvantages, the respondents already using AIMS identified ongoing IT maintenance costs and a lack of IT support as key barriers/disadvantages. Fewer respondents documenting on paper identified these as barriers/disadvantages (Table 4). These responses show important differing perspectives on some key barriers and disadvantages between these two groups of respondents. The planning for adequate post-AIMS installation financial and IT support will need to be considered carefully by both those currently using AIMS and those planning to implement these systems. There is also evidence to suggest that AIMS can contribute to a positive net return on investment for anesthesia departments because of increased revenue.^{27,28} Nevertheless, the exact return on investment will depend on each institutions' particular financial, billing, and management practices.^{27,28}

The concern regarding technical support dedicated specifically to AIMS is certainly warranted. The technical support required for the planning, implementation, and maintenance phases of an AIMS installation is substantial. Once an AIMS is installed and running smoothly, there is still a need for 24/7 technical and reference support. It must be emphasized that this support cannot be managed solely by technical support personnel but requires a dedicated AIMS support team with developing or advanced subject matter expertise in perioperative anesthesia practice.^{29–32} In addition, “physician champions”, who are defined as “physician leaders who facilitate the change necessary to implement a new HIT system within the organization”, may help bridge perception gaps.^{31,33} These physician champions may provide emotional, peer, and educational support to anesthesia providers as well as identifying opportunities for cost-saving or revenue generation.³³ Interestingly, while most (83.3 %) respondents still documenting on paper perceived that AIMS would enable quality improvement initiatives, only 63.9% of those using AIMS identified this advantage. This difference may be due to several reasons, including poor implementation and the lack of expertise in extracting data from the AIMS.

Knowledge exchanges and the ability to share lessons across institutions on the same systems may help alleviate some of these barriers and disadvantages. We provide data on the exact AIMS systems being implemented at the surveyed academic anesthesia departments and hospitals across Canada (Table 2).

Our study has several limitations. First, the accuracy of the responses from the participants cannot be guaranteed. Nevertheless, we have no reason to suspect that any respondent misrepresented the status of AIMS or health informatics expertise in their department. Second, given that only one reply was obtained per department, the perceptions of AIMS advantages and disadvantages are limited to the respondents only and not all departmental members. Nevertheless, the respondents were identified as most the appropriate individuals to provide information on the subject matter. Third, our study only included academic anesthesia departments and the results cannot be extrapolated to non-academic departments. Finally, given that large-scale health information implementation projects may be provincial governmental decisions, plans regarding future AIMS installations might have been cancelled or planned implementations might have been initiated after our study was conducted.

In summary, this study is the first to examine AIMS adoption and health informatics expertise in Canadian academic anesthesia departments. Most departments surveyed are still using paper anesthesia records, but this trend is expected to reverse in the next five years as more departments install AIMS. For the known AIMS vendors, the top three by 2024 are expected to be EpicTM, CernerTM, and GETM. Health informatics expertise is lacking in most of the departments, and most departments are either not planning or not sure about supporting future anesthesia informaticians. In terms of AIMS adoption, Canadian academic anesthesia departments are lagging their U.S. counterparts by more than ten years.

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