Drug shortages in Canadian anesthesia: a national survey

Pénuries de médicaments pour l'anesthésie au Canada: une enquête de pratique nationale

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Abstract

Background Canadian physicians are faced with an increasing frequency of drug shortages. We hypothesized that drug shortages have a clinical impact on anesthesia care in Canada.

Methods We conducted a self-administered survey of anesthesiologists in Canada using the membership list of the Canadian Anesthesiologists' Society. For survey development, we identified key domains, including types of drug shortages, impact on the ability of anesthesia practitioners to provide general anesthesia care, and impact on patient outcomes. We undertook assessments of face validity, clinical sensibility, and content validity. Respondents were surveyed from January–April 2012.

Results Completed valid questionnaires were submitted by 1,187 respondents (61.4%), and 779 (65.7%) of respondents described a shortage of one or more anesthesia or

critical care drugs. Changes in anesthesia practice resulting from drug shortages were common; 586 (49%) respondents thought they had given an inferior anesthetic, and 361 (30%) reported administering medications with which they were unfamiliar. Respondents also reported that drug shortages were, at times, responsible for changes in the conduct of patient care, with 28 (2.4%) noting cancellation or postponement of surgery and 92 (7.8%) witnessing a drug error. One hundred sixty-five (13.9%) respondents regarded drug shortages as having prolonged recovery from anesthesia, and 124 (10.5%) viewed drug shortages as resulting in an increased number of postoperative complications, such as postoperative nausea and vomiting.

Interpretation Drug shortages are common in anesthetic practice in Canada. This state of affairs may have a negative effect on how anesthesiologists practice anesthesia and may be associated with adverse patient outcomes.

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Résumé

Contexte *Les médecins canadiens font de plus en plus souvent face à des pénuries de médicaments. Nous avons émis l'hypothèse que les pénuries de médicaments avaient un impact sur les soins en anesthésie au Canada.*

Méthode *Nous avons réalisé un sondage auto-administré auprès des anesthésiologistes au Canada en nous fondant sur la liste des membres de la Société canadienne des anesthésiologistes. Lors de la mise au point du sondage, nous avons déterminé des domaines clés, notamment les types de pénuries de médicaments, l'impact sur la capacité des fournisseurs d'anesthésie à offrir des soins d'anesthésie générale, et l'impact sur les devenir des patients. Nous avons évalué la validité apparente, la sensibilité clinique, et la validité du contenu. Les répondants ont reçu le sondage entre janvier et avril 2012.*

Résultats *Au total, 1187 (61,4 %) répondants ont complété des questionnaires de façon valable, et 779 (65,7 %) de ces répondants ont décrit une pénurie d'un médicament ou plus utilisé en anesthésie ou en soins critiques. Les changements dans la pratique de l'anesthésie dus à des pénuries de médicaments étaient courants; 586 (49 %) répondants estiment avoir donné une anesthésie de moins bonne qualité, et 361 (30 %) ont rapporté avoir administré des médicaments qu'ils ne connaissaient pas bien. Les répondants ont également rapporté que les pénuries de médicaments étaient parfois responsables de changements au niveau des soins aux patients; en effet, 28 (2,4 %) répondants ont noté une annulation ou un report de chirurgie et 92 (7,8 %) ont été témoins d'erreurs médicamenteuses. Cent soixante-cinq (13,9 %) répondants considèrent que les pénuries de médicaments ont retardé la récupération suite à une anesthésie, et 124 (10,5 %) les voient comme entraînant un nombre accru de complications postopératoires, tels que les nausées et vomissements postopératoires.*

Interprétation *Les pénuries de médicaments sont courantes dans la pratique de l'anesthésie au Canada. Cette situation pourrait avoir un effet négatif sur la façon dont les anesthésiologistes pratiquent l'anesthésie et être associée à des devenir de patients défavorables.*

The shortage of critical drugs has been identified as a problem for practitioners.¹⁻³ The impact of drug shortages ranges from minor inconvenience⁴ to major adverse

events.⁵ The incidence of drug shortages is accelerating.⁶ Adverse effects of drug shortages in oncology,^{7,8} psychiatry,⁹ and infectious disease^{10,11} have been reported, but there is a paucity of data reflecting the effects of drug shortages on the practice of anesthesia or critical care.^{4,5,12}

In a 2011 survey conducted by the American Hospital Association, 95% of respondents indicated that drugs for anesthesia and surgery were in short supply.¹³ Another survey conducted by the American Society of Anesthesiologists (ASA) revealed that drug shortages in anesthesia were associated with adverse patient outcomes, including death.^{14,15} Similar shortages have been reported in Canada where three distributors supply 90% of the drugs utilized in Canadian hospitals, and one manufacturer (Sandoz) supplies 80% of injectable drugs.¹⁶ There is growing professional^{16,17} and public concern¹⁸ that drug shortages may be affecting patient care, but limited data exist to support or refute this concern. We undertook a nationwide survey of members of the Canadian Anesthesiologists' Society (CAS) to determine the frequency of practitioner reports pertaining to: 1) anesthetic and critical care drug shortages; 2) changes in the conduct of anesthetic care resulting from drug shortages; and 3) adverse patient outcomes associated with drug shortages, including prolongation of recovery from anesthesia, prolonged post-operative nausea and vomiting, or death. We hypothesized that drug shortages were having a clinical impact on patient care.

While we were conducting this survey, Sandoz announced the closure of its manufacturing plant in Boucherville, Québec on February 7, 2012.^{19,20} This afforded us a unique opportunity to examine the impact of this plant closure on the delivery of anesthesia care.

Methods

We used the CAS membership list to conduct a self-administered survey of physicians (certified anesthesiologists and general practitioners) providing general anesthesia in healthcare facilities in Canada. Approval was obtained from the Capital District Health Authority Research Ethics Board prior to implementing the study (CDHA-RS/2012-177 approval date 11 Oct 2011).

Questionnaire development

Domains and items generation

We identified key domains in the area of drug shortages using the ASA Drug Shortages Survey, 2012¹⁴ as a working template (with permission). These included the types of drugs, the impact on the ability of anesthesia

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practitioners to provide general anesthesia care, and the impact on patient outcomes. Using these domains, we generated a list of questions from amongst a group of investigators with clinical expertise in anesthesiology and/or methodological expertise in conducting surveys. The survey also contained questions relating to physician demographics, including age, place of practice, duration of practice, and the number of days practiced per week. An iterative process was applied to refine the questions.

The Appendix provides a copy of the questionnaire.

Questionnaire testing

Face validity and clinical sensibility testing

We assessed the comprehensiveness and clarity of the questionnaire using a five-point Likert scale. A group of seven anesthesiologists not involved in the development of the questionnaire completed the assessment using an adaptation of a structured instrument developed by Burns *et al.* for this purpose.²¹ As a result of this process, we made changes to the original instrument to improve clarity.

Content validity

To ensure that the topics covered in the survey were in accordance with the stated objectives, a different group of seven anesthesiologists were asked to assess the comprehensiveness of the domains and items addressed in the questionnaire and to comment on the survey. No key domains were identified as missing.

Test-retest reliability

We then asked ten Canadian anesthesiologists to complete the survey twice, two weeks apart. This process resulted in a test-retest agreement rate (where agreement is defined as the same response on both occasions) of 71%, obtained by averaging over the seven questions addressing drug shortages and over the ten anesthesiologists.

Survey administration

We sent the survey link electronically at the beginning of 2012 (Period 1). Non-respondents were given a second opportunity via E-mail in mid-February (Period 2) and a third opportunity at the beginning of March (Period 3). We used FluidSurveysTM software (Ottawa, ON, Canada) to collect the data. Canadian Anesthesiologists' Society members without an E-mail address or with one that was incorrect as well as non-respondents after the third E-mail received a paper copy of the questionnaire with a

self-addressed stamped envelope (Period 4). Data are reported for responses received up to June 4, 2012.

Sample size

Previous postal surveys conducted on behalf of the CAS yielded response rates from 49–57%.^{22–24} Considering the size of the CAS data set of active members and post-residency physicians ($n = 1,932$) and an expected 60% rate of response, we estimated the final sample size to be 1,159 respondents. This sample size would yield a maximum 95% confidence interval (CI) half-width of 3%.

Analyses

The data were analyzed using SAS® 9.2 (SAS Institute Inc., Cary, NC, USA). We calculated the percentage of respondents experiencing a shortage of each drug, the percentage of those whose anesthesia practice was impacted by drug shortages, and the percentage of those with specific adverse patient outcomes attributed to drug shortages. The Mantel-Haenszel (MH) Chi square test with one degree of freedom²⁵ was used to investigate trends over the four time periods during data collection. Multivariable logistic regression models were used to investigate how the reporting of drug shortages varied with calendar time, with the practitioners' number of years of experience, with the number of days practiced per week, and with the type of practice. Similar models were used to determine if these factors were associated with the occurrence of drug shortage-related adverse patient outcomes.

Results

Survey population

We received 1,293 responses from the 1,932 listed active CAS members and post-residency physicians; 106 of these were blank due to specified (i.e., not currently practicing) or unspecified reasons. The remaining 1,187 respondents (61.4% of listed CAS members) provided valid completed questionnaires (Figure 1). The numbers of respondents in the four periods were: Period 1, $n = 438$; Period 2, $n = 238$; Period 3, $n = 253$; and Period 4, $n = 258$. Table 1 provides demographic information. Respondents were practitioners in all Canadian provinces, the Northwest Territories, and the Yukon. Most respondents had practiced for at least ten years (69%), were delivering anesthesia five days per week (56%), and worked in academic centres (52%) — although a significant number were in community practice (40%).

Reports of drug shortages

Most respondents (779/1,187, 65.6%) described a current shortage of one or more anesthesia or critical care drugs (Table 2). The proportion of respondents reporting a current drug shortage varied over time: Period 1, 60%; Period 2, 61%; Period 3, 76% (following closure of the Sandoz plant in Boucherville, QC, Canada); and Period 4, 70%. This increase, particularly in Phase 3 (March 2012), was unlikely due to chance (MH Chi square = 13.8; $P = 0.001$). The logistic regression analysis showed that respondents who had been in practice for a longer period of time were less likely to report a current drug shortage (odds ratio [OR] = 0.87 per five years in practice; 95% CI = 0.80 to 0.95; $P = 0.001$). Table 3 shows the trend analysis for each drug and each drug class over the four time intervals. For 11 of the 18 drugs, there was a statistically significant increase in respondent reports of a drug shortage over time. For two drugs (propofol and succinylcholine), there was a significant decrease in the reporting of a shortage over time, and for five drugs, there was no significant trend.

Reported changes in the conduct of anesthesia and critical care

Changes in anesthesia practice resulting from drug shortages were common (Table 4). There were 586 respondents (49%) who thought they had administered an inferior anesthetic, and 361 (30%) respondents reported administering medications with which they were unfamiliar. Administering unfamiliar medications was more common among less experienced practitioners (OR = 0.85 per five years in practice; 95% CI = 0.78 to 0.93; $P < 0.001$). Twenty-eight respondents (2.4%) noted cancellation or postponement of surgery, and 92 (7.8%) witnessed a drug error. There were 265 (22.3%) respondents who thought drug shortages had negatively impacted patient care, and 354 (29.8%) respondents thought drug shortages had increased the cost of perioperative care.

Qualitative comments

When asked if they had any additional comments, respondents identified three areas of concern: 1) Increased cost (20 responses), e.g., “Had to use more expensive drugs”; 2) Safety issues (25 responses), e.g., “Several close calls with our technicians stocking our carts and putting similar looking vials in the wrong places in our carts”; and 3) Practice changes (28 responses), e.g., “Using alternate drugs that are equivalent (oral Zofran, instead of intravenous, oral nonsteroidal anti-inflammatory drugs [NSAIDs] instead of intravenous ketorolac)”.

Fig. 1 Survey flow diagram

Effects on patient outcomes

Only a minority of respondents (248, 21%) thought drug shortages had affected patient outcomes (Table 5); however, 165 (13.9%) respondents thought drug shortages prolonged

Table 1 Demographics of 1,187 respondents

Variable	Number of Respondents <i>n</i> (%)
<i>Province of Practice</i>	
Newfoundland	21 (1.8)
Prince Edward Island	3 (0.3)
Nova Scotia	59 (5.0)
New Brunswick	29 (2.4)
Quebec	205 (17.3)
Ontario	454 (38.3)
Manitoba	59 (5.0)
Saskatchewan	51 (4.3)
Alberta	130 (11.0)
British Columbia	173 (14.6)
Yukon	1 (0.1)
Northwest Territories	1 (0.1)
Not reported	1 (-)
<i>Years in Practice</i>	
< 5	174 (15.5)
5- < 10	170 (15.2)
10- < 15	175 (15.6)
15- < 20	139 (12.4)
≥ 20	461 (41.2)
Not reported	68 (-)
<i>Days Delivering Anesthesia per Week</i>	
≤ 1	12 (1.1)
2	36 (3.2)
3	148 (13.2)
4	261 (23.3)
≥ 5	661 (59.1)
Not reported	69 (-)
<i>Primary Place of Practice</i>	
Community hospital	478 (42.8)
Academic medical centre	618 (55.3)
Private medical clinic	16 (1.4)
Other	5 (0.4)
Not reported	70 (-)

recovery from anesthesia, and 124 (10.5%) viewed drug shortages as having resulted in an increased number of post-operative complications. These postoperative complications increased over time (Table 6). There were only 27 (2.3%) respondent reports of patient complaints due to drug shortages. Four respondents reported a perioperative death attributable to anesthesia and critical care drug shortages. Through the duration of the study, we observed a trend toward an increased risk of perioperative complications over time (Table 6).

Qualitative comments

When asked if they had any additional comments, respondents identified four areas of concern: 1) Adverse

Table 2 Distribution of reported drug shortages

Drug	Current Shortage Yes/Total (%)	Shortage in Past 12 Months Yes/Total (%)
Propofol	77/1,187 (6.5)	212/1,187 (17.9)
Succinylcholine	81/1,187 (6.8)	172/1,187 (14.5)
Epinephrine	23/1,187 (1.9)	30/1,187 (1.5)
Neostigmine	93/1,186 (7.8)	65/1,187 (5.5)
Glycopyrrolate	184/1,186 (15.5)	114/1,187 (9.6)
Heparin	31/1,187 (2.6)	32/1,187 (2.7)
Ephedrine	257/1,185 (21.7)	326/1,187 (27.5)
Phenytoin	14/1,187 (1.2)	9/1,187 (0.8)
Vasopressin	34/1,187 (2.9)	39/1,187 (3.3)
Adrenergic receptor blocking agent	13/1,187 (1.1)	13/1,187 (1.1)
Other anesthetic agent, e.g., ketamine	70/1,187 (5.9)	54/1,187 (4.6)
Local anesthetic agent, e.g., chloroprocaine	9/1,187 (0.8)	11/1,187 (0.9)
NSAID, e.g., ketorolac	49/1,187 (4.1)	38/1,149 (3.2)
Anticholinergic agent, e.g., atropine	1/1,187 (0.1)	6/1,181 (0.5)
NMBA, e.g., rocuronium	64/1,187 (5.4)	74/1,187 (6.2)
Vasoconstrictor, e.g., norepinephrine	109/1,187 (9.2)	46/1,187 (3.9)
Antiemetic	79/1,186 (6.7)	45/1,187 (3.8)
Opioid, e.g., fentanyl	275/1,187 (3.2)	180/1,187 (15.2)
Any drug	779/1,187 (65.6)	942/1,187 (79.5)

Current = within the past 30 days. NSAID = nonsteroidal anti-inflammatory drug; NMBA = neuromuscular receptor blocking agent

events (96 responses), e.g., “Hypertension in ketorolac/phenylephrine mix up”; 2) Caregiver stress (25 responses), e.g., “Increased stress potentially causing worse anesthetic ability” and “frustration at not being able to provide optimum patient care to best of my ability”; 3) Legal action (two responses); and 4) Improved care (four responses), e.g., “Some changes have improved outcomes, e.g., fentanyl removed from labour epidurals has resulted in less pruritis; fentanyl removed from spinal also containing Epimorph has saved cost without impact on quality of anesthesia; encouraged premedication with oral drugs (pre-emptive analgesia with Tylenol ± NSAID)”.

Discussion

In our study, approximately 66% of Canadian anesthesia practitioners reported drug shortages of some kind during the first four months of 2012. Respondents considered drug shortages to have had a significant impact on the delivery of anesthetic care, both at the practitioner and patient

Table 3 Drug shortage trend over the four time intervals (number and percent of respondents reporting a shortage within the past 30 days)

Variable	Period 1 (n = 438)	Period 2 (n = 238)	Period 3 (n = 253)	Period 4 (n = 258)	Trend*	P value**
Propofol	41 (9.4)	11 (4.6)	21 (8.3)	4 (1.6)	↓	<0.001
Succinylcholine	53 (12.1)	9 (3.8)	9 (3.6)	10 (3.9)	↓	<0.001
Epinephrine	4 (0.9)	3 (1.3)	5 (2.0)	11 (4.3)	↑	0.003
Neostigmine	5 (1.1)	6 (2.5)	27 (10.7)	55 (21.4)	↑	<0.001
Glycopyrrolate	8 (1.8)	19 (8.0)	73 (28.9)	84 (32.7)	↑	<0.001
Heparin	8 (1.8)	3 (1.3)	10 (4.0)	10 (3.9)	↑	0.038
Ephedrine	112 (25.6)	41 (17.3)	47 (18.5)	57 (22.2)	–	0.175
Phenytoin	0 (0)	4 (1.7)	5 (2.0)	5 (2.9)	↑	0.011
Vasopressin	4 (0.9)	9 (3.8)	7 (2.8)	14 (5.4)	↑	0.001
Adrenergic Receptor Blocking agent	5 (1.1)	2 (0.8)	4 (1.6)	2 (0.8)	–	0.882
Other anesthetic agent	4 (0.9)	2 (2.9)	27 (10.7)	32 (12.4)	↑	<0.001
Local anesthetic agent	6 (1.4)	1 (0.4)	0 (0)	2 (0.8)	–	0.196
NSAID	0 (0)	1 (0.42)	7 (2.8)	41 (15.6)	↑	<0.001
Anticholinergic agent	1 (0.2)	0 (0)	0 (0)	0 (0)	–	0.275
NMBA	15 (3.4)	6 (2.5)	18 (7.1)	25 (9.7)	↑	0.001
Vasoconstrictor	38 (8.7)	28 (11.7)	20 (7.9)	23 (8.9)	–	0.837
Antiemetic	7 (1.6)	6 (2.5)	13 (5.1)	53 (20.6)	↑	<0.001
Opioid	79 (18.0)	46 (19.3)	86 (34.0)	64 (24.8)	↑	<0.001
Any drug	262 (60)	146 (61.3)	192 (75.9)	179 (69.7)	↑	<0.001

Period 1 = Jan 15 - Feb 14, 2012

Period 2 = Feb 15 - Feb 28

Period 3 = Mar 1 - Mar 30

Period 4 = April 15 - June 4

* Direction of trend based on the sign of the logistic regression parameter estimate.

** As determined by Mantel-Haenszel test for trend.
NSAID = nonsteroidal anti-inflammatory agent;
NMBA = neuromuscular receptor blocking agent**Table 4** Reported effects of drug shortages on anesthesia practice

Effect on anesthesia practice	n	%
Had to give what was considered an inferior anesthetic technique	586	49.4
Had to administer a less familiar anesthetic	361	30.4
Had to postpone procedure	14	1.2
Had to cancel procedure	14	1.2
Had to modify anesthetic technique	299	25.2
Witnessed a drug error	92	7.8
Had to give an alternative drug requiring a change in patient care	265	22.3
At least one of the above	802	67.6

n = number of respondents (out of 1,187) reporting an effect;
% = percentage of respondents reporting an effect

levels. Reports of drug shortages increased following the closure of a major pharmaceutical plant, the Sandoz facility in Boucherville, Québec, exacerbating an already existing problem.

As anesthesiologists struggle with frequent substitutions of less familiar agents, the current rate of drug shortages requires frequent alterations of anesthetic technique and likely explains why respondents in our study think they delivered an inferior and unfamiliar anesthetic. Our data suggest that junior practitioners are more concerned with drug shortages as they may have had less exposure to older agents that have since been replaced by newer drugs prior

to the practitioners' entry into practice. Unfamiliarity with the use of an agent may predispose inexperienced practitioners to errors as they adapt to older and more toxic agents, e.g., neuromuscular receptor blocking agents. Errors may also occur due to mix-ups resulting from the administration of "look alike" agents that have very different drug actions. The sheer number of agents involved in the Sandoz closure has brought this possibility sharply into focus. Reports of surgical cases being cancelled or postponed as a result of drug shortages (e.g., heparin) would likely reflect a further negative impact on patient care.

As we ascertained, there may be adverse patient outcomes occurring due to drug shortages. The short supply of antiemetic drugs identified by respondents and the reported concomitant increase in postoperative nausea and vomiting is just one example of the impact of drug shortage. From a patient's perspective, postoperative nausea and vomiting is one of the most distressing adverse postoperative outcomes,²⁶ and its avoidance is a marker of quality anesthetic care.²⁷⁻³⁰

There were 27 reports of patient complaints, which the respondents thought could be related to drug shortages. We have no details surrounding these events, but in two cases, legal action was reportedly taken, suggesting that patients are beginning to be negatively affected by the current drug shortage.

We express caution in the interpretation of four reports of perioperative deaths, which the respondents suggested were due, in part, to a drug shortage. Since respondents to our survey remain anonymous, we have no means to

Table 5 Reported effects of drug shortages on patient outcomes

Overall <i>n</i> = 1,187	Period 1 <i>n</i> = 438	Period 2 <i>n</i> = 238	Period 3 <i>n</i> = 253	Period 4 <i>n</i> = 258	Trend*	<i>P</i> value**
<i>Post-op complications, including nausea, vomiting, aspiration, n (%):</i>						
124 (10.5)	34 (7.8)	19 (8.0)	28 (11.1)	43 (16.7)	↑	<0.001
<i>Prolonged recovery, n (%):</i>						
165 (13.9)	48 (11.0)	42 (17.7)	41 (16.2)	34 (13.2)	–	0.284
<i>Patient complaint, n (%):</i>						
27 (2.3)	10 (2.3)	3 (1.3)	5 (2.0)	9 (3.5)	–	0.364
<i>Death of a patient, n (%):</i>						
4 (0.3)	0 (0.0)	1 (0.4)	1 (0.4)	2 (0.8)	↑	0.097
<i>At least one of the above, n (%):</i>						
248 (20.9)	73 (16.7)	51 (21.4)	63 (24.9)	61 (23.6)	↑	0.009

Period 1: Surveys returned Jan 15 - Feb 14, 2012

Period 2: Surveys returned Feb 15 - Feb 28

Period 3: Surveys returned Mar 1 - Mar 30

Period 4: Surveys returned April 15 - June 4

* Direction of trend based on the sign of the logistic regression parameter estimate. ** *P* value determined by the Mantel-Haenszel test for trend

confirm or corroborate the details of such incidents. It would have been challenging to discern the role that drug shortages played in those deaths even if further details had been provided. The reports of drug errors attributed to drug shortages should remind all healthcare providers of the importance of safe medication practices in a rapidly changing healthcare environment.

Finally, there is a human and economic cost to dealing with drug shortages.³¹ The human costs identified in this survey included frustration and worry about delivering anesthetics under what was perceived to be suboptimal conditions. The monetary costs of drug shortages are not well recognized. In our survey, 53% of the respondents did not know whether or not the drug shortages were increasing the costs of care. The effects of drug shortages (and the costs of finding suitable alternatives) have largely been hidden by many pharmacists working diligently to find alternative agents or suppliers.³²

Strengths of our study include its national scope and diversity of respondents. The survey was constructed using accepted principles for creation and implementation of such research, and as such, overcomes many of the weaknesses identified for surveys of this kind.³³ Our study is limited by being a convenience sample composed of roughly two-thirds of the membership of the CAS, and it may not reflect the views of the other one-third of the membership or of non-members. While the concordance rate (71%) in the test-retest reliability is not perfect, it may reflect the drug shortage changes (and subsequent impression of impact on practice and patient care) occurring at the time and may have affected this validation phase of the questionnaire. Our survey is subject to recall bias as

respondents who have experienced a drug shortage are more likely to remember and report a reoccurrence than practitioners without such an experience. There may have been a training bias as more experienced practitioners may have had more exposure to older substitute agents in their training than new practitioners; consequently, they would be more familiar with the agents' properties and therefore more comfortable with their substitution. Finally, our survey was conducted from January-April 2012, and the possibility that the drug shortages reported may have been confounded by a seasonal trend cannot be excluded.

In conclusion, drug shortages are common in anesthetic practice in Canada. They negatively affect how anesthesiologists practice anesthesia and negatively impact patient care. The closure during the study period of an important pharmaceutical plant supplying a significant number of hospitals in the country seems to have had a major impact on the anesthetic and perioperative care of Canadians. Our data suggest there is cause for concern, at least regarding the practice of Canadian anesthesiologists. A national strategy for the identification of essential drugs and the management of drug shortages should be developed as a matter of priority. Measures should be considered to prevent drug shortages resulting from closures of sole suppliers, e.g., having at least two suppliers for critical drugs.

Competing interests None declared.

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Appendix. Survey Instrument.

Drug Shortages in Canadian Anesthesia

Adapted from the American Society of Anesthesiologists Questionnaire on Drug Shortages with permission.

Tell us about your current status with respect to drug availability in your workplace.

Question 1. Are any of the following anesthesia/critical care drugs no longer available in your workplace due to a drug shortage? (Check all that apply)

- ☐ Propofol
- ☐ Succinylcholine
- ☐ Thiopental
- ☐ Epinephrine
- ☐ Neostigmine
- ☐ Glycopyrrolate
- ☐ Heparin
- ☐ Ephedrine
- ☐ Phenytoin (Dilantin)
- ☐ Vasopressin
- ☐ None
- ☐ Other _____

Question 2. Are you currently (i.e., within the past 30 days) experiencing shortages of any anesthesia/critical care drugs in your workplace? If No please go to Question 4

- ☐ Yes
- ☐ No

Question 3. Which of the following anesthesia/critical care drugs currently are (i.e., within the past 30 days) in limited or intermittent supply. Please disregard any drug you checked in Question 1. (Check all that apply)

- ☐ Propofol
- ☐ Succinylcholine
- ☐ Thiopental
- ☐ Epinephrine
- ☐ Neostigmine
- ☐ Glycopyrrolate
- ☐ Heparin
- ☐ Ephedrine
- ☐ Phenytoin (Dilantin)
- ☐ Vasopressin
- ☐ Other Please indicate _____

Now tell us about your experiences with drug shortages over the past 12 months

Question 4. Has your workplace experienced any anesthesia/critical care drug shortages in the past 12 months? If No please go to Question 6.

- ☐ Yes
- ☐ No

Question 5. What anesthesia/critical care drug shortages has your work place experienced in the past 12 months? Please disregard any drug which you checked in Question 1. (Check all that apply)

- ☐ Propofol
- ☐ Succinylcholine
- ☐ Thiopental
- ☐ Epinephrine
- ☐ Neostigmine

- ☐ Glycopyrrolate
- ☐ Heparin
- ☐ Ephedrine
- ☐ Phenytoin (Dilantin)
- ☐ Vasopressin
- ☐ Had to use alternate drugs with impact on patient care
- ☐ No impact
- ☐ Other _____

Now tell us about the impact drug shortages have had on your practice?

Question 6. How has a drug shortage impacted your practice? (Check all that apply)

- ☐ Had to use alternate drugs considered to be inferior for the indicated anesthetic
- ☐ Had to use less familiar agents
- ☐ Had to postpone cases
- ☐ Had to cancel cases
- ☐ Had to change/modify the anesthetic/surgical procedure
- ☐ Witnessed drug error as a result of frequent substitution of "look alike" drugs from alternate suppliers
- ☐ Had to use alternate drugs with impact on patient care
- ☐ No Impact
- ☐ Other – Please specify _____

Question 7. How has a drug shortage impacted your patients? (Check all that apply)

- ☐ Has resulted in death of a patient
- ☐ Has resulted in a higher rate of postoperative complications (e.g., postoperative nausea and vomiting; aspiration pneumonia)
- ☐ Has resulted in longer OR, PACU, or ICU recovery times
- ☐ Has resulted in complaints from patients
- ☐ No impact
- ☐ Other Please specify _____

Question 8. Please feel free to add description of any adverse event you consider important and was omitted.

Tell us about your demographics.

Question 9. In which province do you mainly practice?

- ☐ British Columbia
- ☐ Alberta
- ☐ Saskatchewan
- ☐ Manitoba
- ☐ Ontario
- ☐ Quebec
- ☐ New Brunswick
- ☐ Nova Scotia
- ☐ Prince Edward Island
- ☐ Newfoundland
- ☐ The North West Territories
- ☐ Yukon

Question 10. You have been in practice

- ☐ < or equal to 5 years
- ☐ >5 to 10 years
- ☐ >10-15 years
- ☐ >15-20 years
- ☐ >20 years

Question 11. On average I practice Anesthesia

- ☐ < or equal to 1 day/wk
- ☐ 2 days/wk
- ☐ 3 days/wk
- ☐ 4 days/wk
- ☐ 5 days/wk or more

Question 12. I practice in

- ☐ A community hospital
- ☐ An academic medical centre
- ☐ A free standing private medical clinic
- ☐ A private office
- ☐ Other (Please specify) _____

Question 13. I participate in emergency surgery

- ☐ Yes
- ☐ No

Question 14. Do you believe that drug shortages have increased the costs of care in anesthesiology

- ☐ Yes
- ☐ No
- ☐ Don't know or unsure

Thank you for your participation in this survey.

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