Medication errors in anesthetic practice: a survey of 687 practitioners

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Purpose: The objectives of this study were to determine: 1) if anesthesiologists had experienced a medication error and 2) to identify causal factors. The perceived value of a Canadian reporting agency for medication errors and improved standards for labels on drug ampoules was also investigated.

Methods: A self-reporting survey was mailed to members of the Canadian Anesthesiologists' Society (n = 2,266). Respondents provided free-text descriptions of medication errors and answered fixed response questions.

Results: Surveys from 687 anesthesiologists (30% response rate) revealed that 85% of the participants had experienced at least one drug error or "near miss". Although most errors (1,038) were of minor consequence (98%), four deaths were reported. The commonest error involved the administration of muscle relaxants instead of a reversal agent. "Syringe swaps" (70.4%) and the misidentification of the label (46.8%) were common contributing factors. Anesthesiologists (97.9%) reported that they read the ampoule label "most of the time" although the label colour was an important secondary cue. Approximately half of the participants would report the error if a reporting program existed and 84% agreed that improved standards for drug labels would reduce the incidence of error.

Conclusions: Most anesthesiologists experienced at least one drug error. The commonest error was a "syringe swap" that involved a muscle relaxant. Most errors were of minor consequence, however, serious morbidity and mortality resulted from clearly preventable events. These results support the development of improved standards for drug labels and the establishment of a Canadian reporting program for medication errors.

Objectif : 1) Découvrir si les anesthésiologistes ont vécu l'expérience d'une erreur de médication et 2) en déterminer les facteurs de causalité. Aussi, on a étudié la valeur perçue d'une agence de notification canadienne des erreurs de médication et de normes strictes des étiquettes d'ampoules de médicaments.

Méthode : Une enquête d'autodéclaration a été postée aux membres de la Société canadienne des anesthésiologistes (n = 2,266). Les répondants ont fourni des descriptions en textes libres des erreurs de médication et ont répondu aux questions à réponses fixes.

Résultats : Les réponses reçues de 687 anesthésiologistes (taux de réponse de 30 %) ont révélé que 85 % des participants avaient fait au moins une erreur de médicament ou l'avait évitée de justesse. Même si la plupart des erreurs (1,038) n'ont eu que des conséquences mineures (98 %), quatre décès ont été rapportés. L'erreur la plus fréquente concernait l'administration de myorelaxants à la place de décurarisants. "L'échange de seringue" (70,4 %) et la mauvaise identification de l'étiquette (46,8 %) étaient souvent des causes d'erreur. Certains (97,9 %) ont dit lire l'étiquette sur l'ampoule "la plupart du temps" même si la couleur de l'étiquette était un important signal secondaire. La moitié des participants environ auraient mentionné l'erreur si un programme de notification avait existé et 84 % croyaient que des normes plus strictes d'étiquetage des médicaments pouvaient réduire l'incidence d'erreur.

Conclusion : La plupart des anesthésiologistes ont expérimenté au moins une erreur de médicament. L'erreur la plus fréquente a été "l'échange de seringue" pour un myorelaxant. Même si, en général, les conséquences sont mineures, une morbidité et une mortalité préoccupantes ont découlé d'incidents qu'on aurait pu certainement prévenir. Ces résultats incitent la mise au point de normes plus strictes pour l'étiquetage des médicaments et l'établissement d'un programme canadien de notification des erreurs de médication.

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MEDICATION error is a leading cause of morbidity and mortality in hospitalized patients.[1] An estimated 180,000 patients die in the United States each year as a result of adverse medical events and medication error is a leading contributing factor. To place this mortality rate in context, the number of medical error-related death far exceeds the mortality associated with automobile crashes (45,000).[2] In addition to personal loss, adverse drug events impose a considerable financial burden to health care systems. The annual cost of medication-related problems in one university hospital was estimated to be $1.5 M.[3] Thus, effective strategies that reduce medication error would enhance patient safety and represent a cost-savings opportunity.

The incidence of medication error associated with anesthetic practice is not certain. However, given the potency, variety, and frequency of the drugs administered to patients undergoing anesthesia, the potential exists for errors with disastrous consequences. Not surprisingly, several studies indicate that medication error is a common adverse event in patients undergoing anesthesia.[4] Another study reported that the incidence of medication error was secondary only to the incidence of airway-related mishaps.[5] Analysis of critical incidences by Cooper and colleagues showed that the number of drug-related events far exceeded the next most common problem, disconnection of the breathing circuit.[6] The Australian Incident Monitoring Study analyzed adverse events during anesthesia and reported that, "the wrong drug" was the most common adverse event.[7] Indeed, anesthetic drug errors have been reported for every aspect of anesthetic-related care.[8–11]

The current study arose from the recommendations resulting from the risk-management analysis of a near-fatal anesthetic drug error.[12] The error involved the administration of epinephrine instead of glycopyrrolate. The review panel proposed the following changes: 1) education to increase awareness regarding the risks of medication errors; 2) a review of the standards for the labeling and packaging of drug ampoule and vials; 3) development of a national reporting program for drug errors and 4) research to identify effective strategies that reduce the incidence of medication error.

The purpose of this study was to determine the frequency and cause of medication errors in patients undergoing anesthesia. Anesthesiologists were asked to describe medication errors or "near-misses" in order to identify the common causal or contributing factors. Here we define a "near miss" as an event that did not involve the actual administration of a drug. In addition, practitioners were asked if they would report the error to national reporting agency and whether improved standards for drug labels would reduce the incidence of drug error.

Methods

A self-reporting survey was designed by the authors in collaboration with members of the Department of Biostatistics and Epidemiology, Sunnybrook Health and Women's College Health Science Centre, and the Labeling Committee of the Pharmaceutical Manufacturing Association of Canada. (Appendix). The survey was composed of four sections. The first section requested information concerning the number of years of anesthetic training, the percentage of time spent administering anesthetics, the level of training (Fellow of the Royal College of Physicians and Surgeons of Canada or equivalent national certification) and the location of the practice. The second section asked if the respondent had ever administered the wrong drug during the conduct of an anesthetic. The survey form provided space for a free-text description of the incident and associated outcome. The outcome of the error was ranked as being of no clinical significance, minor morbidity, major morbidity or death. Potential contributing factors were listed and respondents were asked to identify the factors that were relevant to the incident. More than one factor could be identified for each event. In the third section, anesthesiologists were asked to indicate the features of the label and package that they considered important for drug identification. Finally, respondents were asked if, and to whom, the errors were reported. If the event had not been reported, they were asked to provide an explanation. The survey was mailed along with a stamped, self-addressed envelope and letter of explanation to every member of the Canadian Anesthesiologists' Society that was registered in 1995. The respondents were assured of anonymity. A postcard that reminded the members to return the survey was mailed eight weeks later. Members were also questioned nine months later at the 53rd meeting of the Canadian Anesthesiologists' Society and asked to complete the survey, if they had not already done so.

The research nurse and an anesthesiologist (RJC) analyzed the data. The results are expressed as absolute numbers and percentages.

Results

Surveys were mailed to all the members of the Canadian Anesthesiologists' Society that were registered in 1995 (n = 2,266). A total of 687 surveys were returned for analysis (30% response rate) and 1,038 drug-related events were described. The average number of events per responder was 1.5.

The demographic profile of the participants is summarized in Figure 1. Most responders had practiced

anesthesia for 5 - 10 yr and were trained as specialists in anesthesia (FRCPC or equivalent certification). Respondents usually practiced in university-affiliated teaching hospitals and spent greater than 75% of their professional time providing clinical care.

A total of 1,038 adverse events were described; 61.7% (n = 424) of responders reported actual errors while 9.6% (n = 66) reported "near misses". A "near miss" is an event in which the drug was not actually administered. Ninety-five of the respondents (13.98%) described both an actual error and "near miss", while a similar number 103 (14.9%) reported that they had never experienced an error (Figure 2).

The reported outcomes of the drug errors are described in Figure 3. The majority of the adverse events were either of minor consequence, (35.4%, n = 368), or no clinical importance, (57.5%, n = 597). Fifteen drug errors (1.4%) resulted in major morbidity (including cardiac arrest, stroke or permanent injury) and four deaths were reported (< 0.4%). The deaths resulted from an overdose of ketamine due to the misidentification of a 50 $mg \cdot ml^{-1}$ vial instead of 10 $mg \cdot ml^{-1}$ vial, administration of norepinephrine instead of fentanyl for sedation in the intensive care unit, potassium chloride solution used to dilute an antibiotic; and peritoneal dialysate infused intravenously for volume resuscitation. A description of the most frequent nonfatal errors is provided in Table I.

The misidentification of a syringe or "syringe swap" was the most common cause of error (70.4%, n = 413, Tables I, II). Other contributing factors included a failure to read the label (62.9%, n = 367), and misidentification of the drug ampoule or vial (46.8%, n = 274).

When asked, "In your estimation, how often do you actually READ the drug name on the label if you are working in your usual workplace?" surprisingly most anesthesiologists reported that they do so only infrequently (Table III). Many responders identified colour as the single most important feature used to identify drugs (Table IV). Of lesser importance was the drug name and the size and shape of the container. When asked to rate the importance of certain feature(s) of the package and label they used for identification, colour was the most frequent response. Surprisingly, the colour of the ampoule and its label were cited as "extremely important" for ampoule recognition. Similarly, the colour of a vial and cap were considered "extremely important". For prefilled syringes, the text colour and external packaging were considered "extremely important". For self-prepared syringes, the syringe size and drug label were the most important features. Other features that were not considered as important included needle gauge and leaving the needle inserted into the drug vial or ampoule.

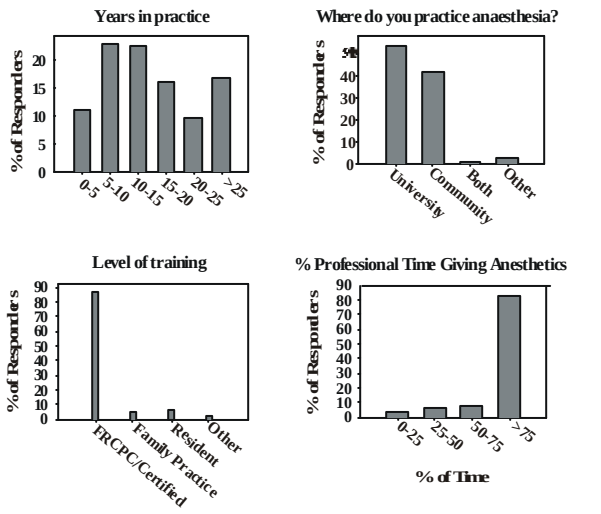

FIGURE 1 Demographics of the responders

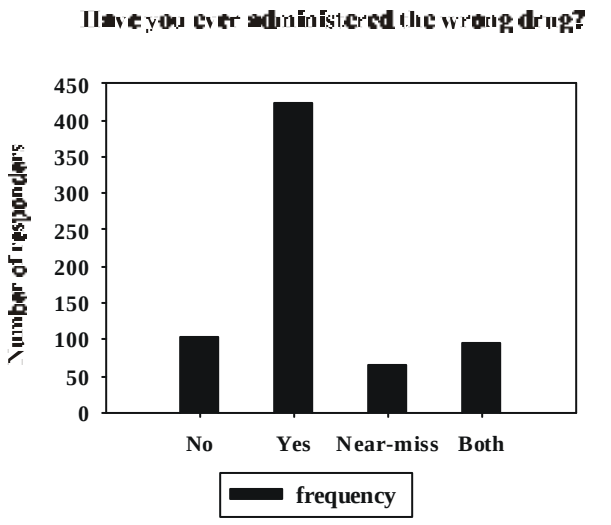

FIGURE 2 Occurrence of medication errors

Most anesthesiologists (86.5% = 594) were aware of the self-adhesive, user applied drug labels that were developed by the Canadian Standards Association International (CSA, Standard Z264.3-98) for anesthesia and critical care. However, only 72% (n = 495) of respondents that were aware of the self-adhesive labels, used them regularly. When asked if they believed these labels decrease the incidence of drug errors, 86.9% (n = 597) "agreed" or "strongly agreed". A similar proportion "agreed" or "strongly agreed" that improved stan-

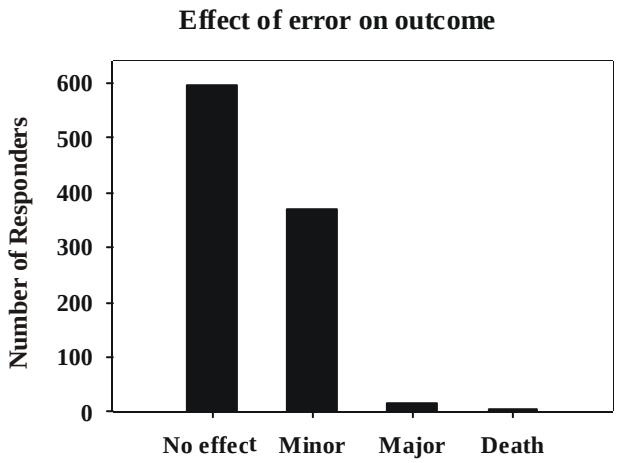

FIGURE 3 Outcome of the medication error

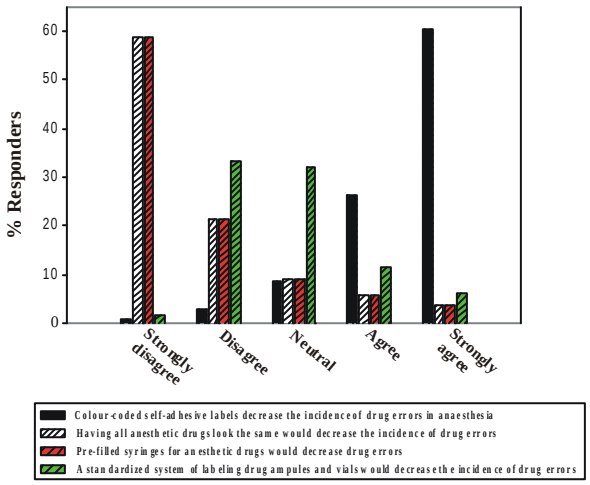

FIGURE 4 Respondent's opinion of strategies to reduce medication error.

TABLE I Frequency of errors

Most frequent errors		
Causes	*Percentage (%)*	*(n)*
Non-depolarizing muscle relaxant when reversal intended	13	132
Succinylcholine when opioid intended	5	52
Opioid when non-depolarizing muscle relaxant intended	4.9	51
Inotrope swapped for another inotrope	3.3	38
Inotrope when anticholinergic was intended	2.5	26

TABLE II Contributing factors

Factors contributing to error	
Factors	*Percentage (%)*
Syringe swap	60
Did not read label	53
Misidenification of ampoule / vial	39
Drug incorrectly stocked	18
Wrong dose injected	10

* Percentages do not sum to 100% because responders often reported more than one factor

TABLE III Reading the label

How often do you read the label?	
Choices	*Percentage (%)*
Never	0
Sometimes	4.6
Most of the time	47.3
Always	47.6

TABLE IV FEATURES FOR IDENTIFICATION

The single most important feature of the label	
Choices	*Percentage (%)*
There is NOT one feature on the label … that helps me…	26.9
Colour of text, label, vial, ampoule or cap	50.7
Drug name or label	7.5
Shape of container	7.1
Size of container	3.4
Drug location, syringe codes	<1

dardized labels would decrease the incidence of medication error (83.8%, n = 576). Only 9.5% (n = 65) felt that having all anesthetic-related drugs similarly labeled and packaged would reduce errors (Figure 4). Most participants did not agree that strategies such as prefilled syringes 17.3% (n = 119) would reduce the number of errors.

The majority of errors identified in the survey have not been reported elsewhere 60.1% (n = 423). Practitioners reported the errors to colleagues (10.4%, n = 72), attending staff at teaching centers (10%, n = 69) or at departmental meetings or rounds (7.5%, n = 52). No errors were reported to provincial or national health agencies. When asked why the errors were not reported, the most common response was that the error was inconsequential (68.3%, n = 469). A further 18% (n = 122) of anesthesiologists were not certain where or to whom the error should be reported. A smaller number of practitioners cited medico-legal concerns (n = 40,

6.0%) or concerns regarding the opinion of their colleagues (5.7%, n = 38). Most patients (83.5%, n = 867) were not informed of the drug error. When asked, "If there were a single reporting agency for anesthetic drug errors, would you have reported the error(s) to this agency?", 234 respondents of 507 (46.1%) agreed that they would report the error. It should be noted that the type of reporting program (e.g., anonymous versus mandatory, self-reporting was not defined in the survey.

Discussion

This report describes the largest number of medication errors in patients undergoing anesthesia that has been published to date. Most anesthesiologists experience at least one actual or potential medication error while in clinical practice. The study confirm several findings from previous reports.[7,13] Notably, most errors were of minor consequence and resulted in no harm to the patient. However, four deaths were reported. The most common medication error was a "syringe swap" that involved the administration of a neuromuscular relaxant when an anticholinesterase was intended. Factors that frequently contributed to other errors included "syringe swap" and misidentification of the ampoule or vial.

Eighty-six percent of respondents were aware of the self-adhesive labels designed by Canadian Standards Association International, but of this group, only 72% used them. Therefore, almost 40% of the responders do not use standardized syringe labels. Most anesthesiologists read drug labels "most of the time" but surprisingly few consider the drug name to be the most important feature used to identify a drug. More than 25% of the responderts reported that there was not a single feature used for identification, rather, an assembly of distinct characteristics was used to identify a drug. For example, one respondent stated that the drug ampoule was identified, "like a face", not by individual elements but rather the whole presentation. Although most of the errors were felt to be of minor consequence, many anesthesiologists were unsure of where or to whom, the events should be reported.

The limitations of a self-reporting survey as a research tool to investigate medication errors are noteworthy. Participants were self-selected and may only report errors they judged to be of sufficient interest or consequence. This introduced a non-responder bias. Also, anesthesiologists may have been reluctant to report all their mistakes. Undoubtedly, the number of errors reported by individual participants was likely low. Most importantly, the Methods do not allow the incidence of error to be determined (as the denominator or number of anesthetics administered is not known). Such limitations could be minimized in prospective studies. Nevertheless, our findings are stimulating and present anesthesiologists with a challenge. On the one hand, the occurrence of medication errors was extremely low, given the number of drugs that were likely administered by the respondents. However, rare events were associated with major morbidity and mortality. The cause of the fatal errors were as diverse as the problems the drugs were intended to treat. In the face of such complexity, how can the medication delivery system be designed to enhance patient safety?

The specialty of anesthesiology has provided leadership in the development of safety standards and analyzing human factors that contribute to error. Because the potential for harm is so great, anesthesiologists are well positioned to "champion the cause" to design and implement safeguards for the medication delivery system. Immediate interventions need to be targeted to individual practitioners. For example, it is essential to educate and raise awareness about the risks of medication error. As standard curriculum, clinical trainees should be informed about the cost of medical error, particularly medication-related adverse events. The concept, "Read The Label" cannot be overemphasized. Also, high-risk drug interventions, such as the administration of an anticholinesterase to reverse muscle relaxants, need to be recognized. However, as stated by James Bagian, a former space shuttle astronaut who was involved in the analysis of the *Challenger* explosion, "Just telling doctors and nurses to be more careful won't do much. We need to change the systems that allow errors to happen".[14]

What additional practical strategies can be implemented to combat medication errors? Punitive strategies are short-sighted and fail to identify the systematic deficiencies that predispose to error. Nevertheless, in some jurisdictions, health care professionals have been convicted of criminal charges as a result of a medication error.[15] Indeed, in Canada, several recent deaths from medication errors were considered to be homicide. Are all anesthesiologists at risk of such criminal charges? It is the opinion of the authors and many other stakeholders (including the Institute of Safe Medication Practice, *www.ismp.org*) that mandatory reporting and blame-oriented approaches do little to remedy the problem.

In a recent landmark publication entitled, "To Err is Human: Building a Safer Health System", strategies to reduce medical errors were proposed.[16] This report was released by the Institute of Medicine Quality of Health Care Committee of the National Academy of Science of the United States. The specialty of anesthe-

siology was cited at least 10 times in the text, in reference to effective interventions adopted by the specialty to increase safety. The report recommended that a Center for Patient Safety be created that would be charged with defining goals, understand why errors occur, and developing a research agenda. Methods to identify and prevent errors and to communicate safety activities are to be developed. The report also recommended improved labeling and packaging standards. The President of the United States, Bill Clinton, endorsed this report and the U.S. Congress was charged with implementing several of the recommendations this year.

At the national level in Canada, several initiatives aimed at reducing medication errors are being developed. A new standard for the labels on ampoules, vials and prefilled syringes for parenteral compounds has recently been published by the Canadian Standards Association International (CAN / CSA-Z264.2-99).[17] The purpose of the standard is to define a minimal performance level and to demand consistency across the pharmaceutical industry. The standard also focuses greater attention on patient safety and defines the performance expectation of health care providers. The objective of the standard was to make labels as legible and unambiguous as possible and address concern that labels were not designed with safety as a primary goal.[18] To date, this standard is not a mandatory regulation and, thus, requires the support of health care professionals. Results of this study suggest that practitioners support improved labeling standards. Consequently, anesthesiologists should demand that medications used in the operating room comply with the standard set by Canadian Standards Association International. Group purchasers have more influence than single practitioners and this demand should be directed to the hospital pharmacists.

Almost half of the participants indicated they would report the error to a national reporting program for medication errors although such a Canadian program does not exist. However, a non-profit organization modeled after ISMP in the United States is under development. The Institute of Safe Medication Practice of Canada (ISMP-Canada, www.ISMP-Canada.org), serves as an *anonymous* practitioner-based reporting program that will collect, analyze and disseminate information regarding medication errors. Practitioners are encouraged to forward reports of errors to this organization. Future research should be directed at the effectiveness of practical, "common-sense" interventions including techniques that reduce reliance on memory, standardization, the use of protocols and checklists, and the elimination of look-alike products.

In summary, this study demonstrates that most anesthesiologists will commit a medication error. This finding is not surprising because the potential for medication error increases as the number of drugs administered increases.[19] The data contradict public opinion that views medical mistakes as an individual provider issue.[20] When asked to identify solutions to prevent medical mistakes, 75% of respondents selected, "keeping health care professionals with bad track records from providing care". Clearly, remedial approaches that simply blame practitioners must be tempered and effective safeguards built into medication delivery systems.

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Appendix

DRUG ERRORS IN ANESTHETIC PRACTICE: ROLE OF LABELING AND PACKAGING

A. Your Anesthetic Practice Profile

1. How many years have you practiced anaesthesia (including residency)? _____

2. Approximately what percent of your professional time is spent administering anaesthetics? _____%

3. What is your training?
   _____FRCPC / Board-certified
   _____Family practice anesthesia
   _____Resident-in-training
   _____Other: Explain_____

4. Where do you practice anesthesia?
   _____University Teaching Center
   _____Community Hospital
   _____Other: Explain_____

B. Prevalence of Drug Errors in Anesthetic Practice

1. In the course of administering anesthesia, have you *ever* given the wrong drug to a patient?
   _____ YES [Please elaborate in question 2]
   _____ALMOST (i.e. "near miss")

[Elaborate in question 2]
_____ NO [Proceed to Section C]

2. Name the drug(s) involved and describe the clinical effects. (e.g. what drug you intended to give, what drug patient received) Use extra sheet to describe if necessary.

EVENT 1_____

EVENT 2_____

EVENT 3_____

3. Did any of the factors listed below contribute to these drug errors? If yes, check one or more box for each event.

	EVENT NUMBER 1	2	3
Misidentification of Ampoule / Vial			
Mislabeling of Syringe			
'Syringe Swap' (wrong syringe injected)			
Did Not Read Label			
Incorrect Drug Injected Stocked in Wrong Location			
Wrong Dose of Drug Injected			
Other (please elaborate below)			

Comments:_____
_____

4. In your opinion, what was the effect of each error on outcome? (Check one box for each event.)

	EVENT NUMBER 1	2	3
Of No Clinical Significance			
Minor Morbidity (required immediate intervention to prevent permanent injury)			
Major Morbidity (e.g. cardiac arrest, stroke or permanent injury)			
Death (only cause or contributory)			

Comments:_____
_____

C. Features of Drug Labeling and Packaging

1. In your estimation, how often do you actually *READ* the drug name on the label if you are working in your *usual workplace*?

a. _____ never c. _____ most of the time
b. _____ sometimes d. _____ always

2. What is *the single most important feature* of the label or container that helps you identify a drug used in the OR or critical care setting on a daily basis?

a. ____There is NOT one feature of the label, container or cap that helps me identify a drug.
b. That one feature is:_____

3. Rate the importance of the following packaging features in assisting identification of anesthetic drugs. [i.e. What characteristics of a drug vial or ampoule direct you to pick that container out from your drug cart when drawing up anaesthetic drugs?] Check off one box for each line.

0 = not important
1 = somewhat important
2 = moderately important
3 = extremely important

Ampoules	0	1	2	3
Color of Ampoule				
Label Colours				
Text Size				
Text Font				
Color Banding on Snap-off Portion				
Size of Ampoule				
Vials	0	1	2	3
Colour of Vial				
Cap Colour on Vials				
Text Color				
Text Size				
Text Font				
Size of Vial				
Shape of Vial				
Pre-filled Syringes	0	1	2	3
Text Colour				
Text Size				
Text Font				
Size of Syringe				
External Packaging (e.g. box)				
Self-prepared Syringes	0	1	2	3
Size of Syringe Used for Specific Drug				
Gauge (Colour) of Needle on Syringe				
Drug Label				
Leaving needle of syringe in opened drug ampoule or vial				

4. Are you aware of the availability of colour-coded, CSA standardized labels for anaesthetic drug syringes? YES NO

5. If yes, do you use these colour-coded self-adhesive labels? YES NO

6. Please indicate your agreement / disagreement with the following by circling a number for each statement:

	Strongly Disagree				Strongly Agree
a. Colour-coded self-adhesive labels decrease the incidence					

of drug errors in anesthesia.	0	1	2	3	4
b. A standardized system of labeling drug ampoules & vials would decrease the incidence of drug errors	0	1	2	3	4
c. Pre-filled syringes for anesthetic drugs would decrease drug errors.	0	1	2	3	4
d. Having *all anesthetic drugs look the same* would *decrease* the incidence of drug errors.	0	1	2	3	4

D. Reporting of Drug Errors in Anesthesia

1. Did you report any of the drug errors identified in Section A? YES NO

2. If yes, to whom or where did you report the error(s)? _____

3. If you did not report the error(s), why not? (Check one or more.)
____ Error was inconsequential
____ Concern regarding the opinion of colleagues
____ Not certain to whom or where the report should go
____ Concern regarding the medical-legal risks involved
____ Other implications of reporting the error
Comments: _____

4. Was the patient notified of the drug error?

	EVENT NUMBER		
	1	2	3
Yes			
No			

5. If there were a single reporting agency for anesthetic drug errors, would you have reported the error(s) to this agency? YES NO

6. What steps (if any) were taken to prevent such a drug error from occurring again?
Explain:_____

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