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Perceptions and reported use of extended reality technology in Royal College-Accredited Canadian Simulation Centres: A national survey of simulation centre directors
Perceptions et utilisation déclarée de la technologie de la réalité étendue dans les centres de simulation canadiens agréés par le Collège royal : une enquête nationale auprès des directeurs de centres de simulation

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Résumé de l'article

Contexte : La technologie de la réalité étendue (RE) est de plus en plus répandue dans l'enseignement médical fondé sur la simulation. Cette étude a examiné les perceptions des directeurs de centres de simulation canadiens à l'égard de la RE et leur adoption déclarée de la RE dans leurs centres.

Méthodes : Nous avons mené une étude nationale transversale pour examiner cinq types de RE : les environnements virtuels immersifs, les mondes virtuels sur écran, les simulateurs virtuels, la réalité augmentée immersive et la réalité augmentée non immersive. Une enquête électronique comportant des questions à choix multiples, des échelles de Likert et des questions ouvertes a été élaborée afin d'identifier l'utilisation actuelle, le degré de satisfaction et les difficultés rencontrées et prévues pour chaque technologie de RE. Nous avons utilisé la Checklist for Reporting Results of Internet E-Surveys pour décrire et justifier l'élaboration de notre enquête. Les vingt-trois centres de simulation canadiens agréés par le Collège royal ont été invités, en fonction de leur appartenance au Collège royal, à répondre à l'enquête. Les directeurs et représentants de dix-sept centres (74 %) ont participé.

Résultats : Chaque RE a été utilisée pour la recherche ou l'enseignement par simulation par environ la moitié des centres de simulation, au minimum. Le degré de satisfaction des directeurs à l'égard de la RE s'est situé entre 30 et 45 %. Les directeurs ont fréquemment cité des défis logistiques et de fidélité, ainsi que des préoccupations concernant la maintenance. Le coût et le manque de preuves, ainsi que l'imprécision des besoins, ont été cités comme des défis prévisibles pour la mise en œuvre future des technologies de RE.

Conclusions : Cette enquête résume l'état d'avancement de la RE dans les centres de simulation canadiens. Le mode d'utilisation, les niveaux de satisfaction et les défis signalés par les directeurs de centre de simulation varient en fonction des types de RE.

Canadian Medical Education Journal

Brief Reports

Perceptions and reported use of extended reality technology in Royal College-Accredited Canadian Simulation Centres: a national survey of simulation centre directors

Perceptions et utilisation déclarée de la technologie de la réalité étendue dans les centres de simulation canadiens agréés par le Collège royal : Une enquête nationale auprès des directeurs de centres de simulation

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Abstract

Background: Extended reality technology (XR) in simulation-based medical education is becoming more prevalent. This study examined Canadian simulation centre directors' perceptions toward XR and their self-reported adoption of XR within their centres.

Methods: We conducted a national, cross-sectional survey study to examine five kinds of XR: Immersive Virtual Environments, Screen-based Virtual Worlds, Virtual Simulators, Immersive Augmented Reality, and Non-immersive Augmented Reality. An electronic survey with multiple-choice, Likert scales, and open-ended questions were developed to identify the current use, degree of satisfaction, and experienced and foreseen challenges with each XR technology. We used the Checklist for Reporting Results of Internet E-Surveys checklist to describe and justify our survey development. All twenty-three Royal College-accredited Canadian simulation centres were invited based on their Royal College membership to complete the survey. Directors and representatives of seventeen (74%) centres participated.

Results: Each XR has been used for research or simulation education by about half of the simulation centres, at minimum. The degree of satisfaction among directors with XR ranged from 30% to 45%. Directors frequently cited logistical and fidelity challenges, along with concerns over maintenance. Cost and lack of evidence, and unclear needs were cited as foreseen challenges with the future implementation of XRs.

Conclusions: This survey summarizes the status of XR in Canadian simulation centres. The pattern of use, satisfaction levels, and challenges reported by simulation centre directors varied depending on the types of XR.

Résumé

Contexte : La technologie de la réalité étendue (RE) est de plus en plus répandue dans l'enseignement médical fondé sur la simulation. Cette étude a examiné les perceptions des directeurs de centres de simulation canadiens à l'égard de la RE et leur adoption déclarée de la RE dans leurs centres.

Méthodes : Nous avons mené une étude nationale transversale pour examiner cinq types de RE : les environnements virtuels immersifs, les mondes virtuels sur écran, les simulateurs virtuels, la réalité augmentée immersive et la réalité augmentée non immersive. Une enquête électronique comportant des questions à choix multiples, des échelles de Likert et des questions ouvertes a été élaborée afin d'identifier l'utilisation actuelle, le degré de satisfaction et les difficultés rencontrées et prévues pour chaque technologie de RE. Nous avons utilisé la *Checklist for Reporting Results of Internet E-Surveys* pour décrire et justifier l'élaboration de notre enquête. Les vingt-trois centres de simulation canadiens agréés par le Collège royal ont été invités, en fonction de leur appartenance au Collège royal, à répondre à l'enquête. Les directeurs et représentants de dix-sept centres (74 %) ont participé.

Résultats : Chaque RE a été utilisée pour la recherche ou l'enseignement par simulation par environ la moitié des centres de simulation, au minimum. Le degré de satisfaction des directeurs à l'égard de la RE s'est situé entre 30 et 45 %. Les directeurs ont fréquemment cité des défis logistiques et de fidélité, ainsi que des préoccupations concernant la maintenance. Le coût et le manque de preuves, ainsi que l'imprécision des besoins, ont été cités comme des défis prévisibles pour la mise en œuvre future des technologies de RE.

Conclusions : Cette enquête résume l'état d'avancement de la RE dans les centres de simulation canadiens. Le mode d'utilisation, les niveaux de satisfaction et les défis signalés par les directeurs de centre de simulation varient en fonction des types de RE.

Introduction

Extended reality (XR), including virtual reality (VR) and augmented reality (AR) has been introduced into simulation-based medical education with expectations of facilitating accessible, self-directed, and interactive learning and providing automated assessments.[1,2] Educators hope these simulation technologies will expedite trainees' learning process to accommodate working hours restrictions during the training period.[3,4]

Our previous study identified that the implementation and evaluation of emerging simulation technology is one of Canadian simulation centres' research priorities.[5] Although several studies showed the effectiveness of educational interventions with XRs on specific skills,[6] the evidence for the cost-effectiveness of education with these technologies is limited.[7] Current research has paid little attention to the perspectives of simulation centre directors who oversee strategic planning and budgeting.[8,9] This is a notable gap because their perspectives, including benefits versus costs, are pivotal in the adoption of technology at Canadian simulation centres.

This study aimed to delineate the utilization of various XR technologies across Canadian simulation centres. We also report, from the perspectives of simulation centre directors, on satisfaction, challenges experienced with current technology, motivation, and anticipated challenges with XR.

Methods

This study was a national cross-sectional survey. The checklist for reporting results of internet e-surveys (CHERRIS)[10] is provided in Appendix A. We identified and derived definitions for five XRs from the XR medical simulation literature.[11-14] These included Immersive Virtual Environment, Screen-Based Virtual World, Virtual Simulator, Immersive AR, and Non-Immersive AR. Each was defined as follows: Immersive Virtual Reality as virtual reality platform that provides a fully immersive environment replacing participants' audiovisual sensory information; Screen-based Virtual World as an artificial virtual world presented through a digital screen surface, which is often provided with a clinical scenario, often looks like a video-game; Virtual Simulator as a simulator for procedural training that depicts a virtual world on a screen AND has a controller or joystick that is interacted with that simulates a surgical tool, such as forceps; Immersive AR as real world annotated by with virtual content viewed through a headset/head-mounted display, and Non-Immersive AR as real world annotated with overlaid virtual content on a screen. These definitions were provided alongside relevant questions to ensure a homogenous understanding among respondents (see caption in Table 1).

The study team developed an online survey using LimeSurvey,[15] a web-based survey platform. The survey included questions about the history of purchase/ownership/lease, and the pattern of use of XRs (for research or education) in the last two years using multiple-choice questions. Further, we asked questions using a 5-point Likert scale about their satisfaction levels with the XRs that had been purchased/owned/leased or used. We also surveyed participants on their motivation for future use of currently unavailable XRs at each institution. Ratings of 4 or 5 were counted as being satisfied and motivated with the use of each XR (where 1 = strongly disagree, 3 = neither agree nor disagree, and 5 = strongly agree to the statements "I am satisfied with [XR]" for satisfaction or "I would like to use [XR] at my simulation centre" for motivation). Table 1 shows the distribution of the levels of satisfaction and motivation with frequency and medians. We only performed descriptive statistics (medians and interquartile ranges (IQRs), and no other statistical analyses were performed.

The survey asked participants about their experienced challenges with XRs and foreseen challenges in future use of XRs using open-ended questions. Answers were categorized based on the aspects of challenges related to XR use based on our codebook (see caption in Table 2), and the frequency of each category was reported (Table 2). We acknowledge that the short responses to open-ended questions in the survey may limit the depth of analysis compared to interview methods, such as semi-structured or focused group interviews. However, we took this approach since the aim of this study was to summarize and deliver up-to-date information on the status of XR usage.

The authors designed the survey to be short, approximately five minutes to be completed, and to have conditional branching to logically reflect the patterns of availability and use of each XR to ensure efficient responses. Branching allowed the survey to be more efficient by limiting response options based on previous answers. For example, when a respondent answered, "have used screen-based virtual world," the respondent would not be asked about their motivation for future use of screen-based virtual worlds. Such adaptive questioning was included in CHERRIES[10] to reduce the number and complexity of the questions.

Table 1. Descriptive statistics about 5 Extended Reality technology in Royal College-accredited Canadian simulation centres.

	Immersive Virtual Environment [a]		Screen-based Virtual World [b]		Virtual Simulator [c]		Immersive AR [d]		Non-immersive AR [e]	
History of purchase or ownership or lease										
	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)
Yes	58.8	10	52.9	9	47.1	8	29.4	5	47.1	8
No	41.2	7	47.1	8	52.9	9	64.7	11	47.1	8
I don't know	0	0	0	0	0	0	5.9	1	5.9	1
History of use over the last two years										
	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)	%	(Frequency/ Total *n* = 17)
Research only	35.3	6	0	0	11.8	2	23.5	4	5.9	1
Simulation education	23.5	4	64.7	11	47.1	8	23.5	4	52.9	9
Never used	35.3	6	29.4	5	41.2	7	47.1	8	29.4	5
I don't know	5.9	1	5.9	1	0	0	5.9	1	11.8	2
Satisfaction level (where 1 = strongly disagree, 3 = neither agree nor disagree, and 5 = strongly agree to the statement "I am satisfied with [XR]" for satisfaction)										
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
	3	3-4	3	3-4	3	2.25-4	3	3-4.25	3	3-4
	%	(Frequency/ Total *n* = 10)	%	(Frequency/ Total *n* = 11)	%	(Frequency/ Total *n* = 10)	%	(Frequency/ Total *n* = 8)	%	(Frequency/ Total *n* = 10)
5	0	0	0	0	10.0	1	25	2	0	0
4	40.0	4	45.5	5	30.0	3	12.5	1	40.0	4
3	50.0	5	54.5	6	30.0	3	62.5	5	50.0	5
2	10.0	1	0	0	30.0	3	0	0	10.0	1
1	0	0	0	0	0	0	0	0	0	0
Motivation for future use (where 1 = strongly disagree, 3 = neither agree nor disagree, and 5 = strongly agree to the statement "I would like to use [XR] at my simulation centre" for motivation)."										
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
	4	4-4	3	3-4	4	3-4	4	4-5	3.5	3-4
	%	(Frequency/ Total *n* = 9)	%	(Frequency/ Total *n* = 9)	%	(Frequency/ Total *n* = 9)	%	(Frequency/ Total *n* = 13)	%	(Frequency/ Total *n* = 10)
5	22.2	2	0	0	22.2	2	30.1	4	0	0
4	66.7	6	44.4	4	44.4	4	46.2	6	50.0	5
3	11.1	1	33.4	3	33.4	3	15.4	2	30.0	3
2	0	0	22.2	2	0	0	7.7	1	20.0	2
1	0	0	0	0	0	0	0	0	0	0

AR: augmented reality. IQR: interquartile range
[a]*Immersive Virtual Reality: virtual reality platform that provides a fully immersive environment replacing participants' audiovisual sensory information;*
[b]*Screen-based Virtual World: an artificial virtual world presented through a digital screen surface, which is often provided with a clinical scenario, often looks like a video-game;*
[c]*Virtual Simulator: a simulator for procedural training that depicts a virtual world on a screen AND has a controller or joystick that is interacted with that simulates a surgical tool, such as forceps;*
[d]*Immersive AR: real world annotated by with virtual content viewed through a headset/head-mounted display;*
[e]*Non-Immersive AR: real world annotated with overlaid virtual content on a screen.*

Inclusion criteria was simulation centres, which were 1) Canadian institutions and 2) accredited by the Royal College of Physicians and Surgeons of Canada (RCPSC). Twenty-three institutions met the criteria. Simulation centre directors' or representatives' contact information was obtained from a publicly available list by the RCPSC and individual websites. Authors sent the initial invitation—including a survey link and informed consent—by email to directors and representatives from the 23 simulation centres with two reminder emails to those who had not responded. Responses were collected between July and September 2023. The Institutional Review Board at McGill University approved this study protocol (A06-E27-23B (23-04-060)).

Results

We received responses from simulation centre directors and representatives from 17 out of 23 simulation centres (73.9%). Responses included simulation centres from Ontario (47.1%, *n* = 8), Quebec (29.4%, *n* = 5), Western Canada (17.6%, *n* = 3), and Eastern Canada (0.6%, *n* = 1).

Nearly or more than half of the 17 institutions (47.1%, n = 8/17 to 58.8%, *n* = 10/17) reported a history of purchasing, owning, or leasing an Immersive Virtual Environment, Screen-based Virtual World, Virtual Simulator, or Non-immersive Augmented Reality. Only 29.4% (*n* = 5/17) of simulation centres have purchased, owned or leased Immersive Augmented Reality. All XR technologies have been used either for research or simulation education purposes by nearly or more than half (47.1%, *n* = 8/17 to 64.7%, *n* = 11/17) of surveyed simulation centres over the last two years (Table 1).

The satisfaction levels of respondents with the XRs currently available and/or used at their simulation centres were 3 in median (on a scale from 1-5) across XRs. Forty to 45.5% of respondents agreed with being satisfied across all XRs (a score of 4 or 5; Table 1, Appendix B). The motivation level to use an XR that was not available at their own institutions was between 3 and 4 in median (on a scale from 1-5). The degree of motivation for future use varied depending on the type of XRs with Screen-based Virtual Worlds being the lowest at 44.4% and Immersive Virtual Environments being the highest at 88.9% (Table 1, Appendix B).

The most frequently reported challenges varied based on technology. Limitations in fidelity and computer teaching (e.g., mapping accuracy in Immersive Virtual Environments and Non-immersive Augmented Reality) and concerns over maintenance were reported across all XRs. Regarding foreseen challenges, cost was indicated as the most common challenge for all XRs as well as ambiguity of educational needs and lack of evidence (Table 2).

Table 2. Frequencies of experienced challenges and foreseen challenges reported by simulation centre directors and representatives.

	Lack of evidence[a]	Limitation of fidelity and computer teaching[b]	User comfort[c]	Unclear educational needs[d]	Maintenance[e]	Scalability and accessibility[f]	Degree of customization[g]	Cost[h]	IT support and technical staff[i]	Rapidly developing markets[j]
Experienced challenges										
Immersive Virtual Environment (*n* =12)	3 (25%)	3 (25%)	3 (25%)	2 (16.7%)	1 (8.3%)	1 (8.3%)	0	0	0	0
Screen-based Virtual World (*n* =10)	1 (10%)	4 (40%)	0	1 (10%)	1 (10%)	0	4 (40%)	3 (30%)	2 (20%)	0
Virtual Simulator (*n* = 10)	0	2 (20%)	0	0	3 (30%)	1 (10%)	1 (10%)	3 (30%)	0	0
Immersive Augmented Reality (*n* = 7)	1 (14.3%)	2 (28.6%)	1 (14.3%)	2 (28.6%)	3 (42.3%)	1 (14.3%)	0	4 (57.1%)	0	0
Non-immersive Augmented Reality (*n* = 6)	2 (33.3%)	1 (16.7%)	0	1 (16.7%)	2 (33.3%)	2 (33.3%)	0	2 (33.3%)	0	0
Foreseen challenges										
Immersive Virtual Environment (*n* = 7)	2 (28.6%)	0	1 (14.3%)	1 (14.3%)	0	0	0	5 (71.4%)	2 (28.6%)	2 (28.6%)
Screen-based Virtual World (*n* = 8)	2 (25.0%)	0	0	3 (37.5%)	0	1	0	3 (37.5%)	0	0
Virtual Simulator (*n* = 8)	2 (25.0%)	0	0	2 (25.0%)	0	0	0	6 (75.0%)	0	0
Immersive Augmented Reality (*n* = 11)	3 (27.3%)	2 (18.2%)	1 (9.1%)	2 (18.2%)	0	1 (9.1%)	0	9 (81.2%)	2 (18.2%)	1 (9.1%)
Non-immersive Augmented Reality (*n* = 8)	1 (12.5%)	0	0	5 (62.5%)	0	0	0	2 (25.0%)	0	0

Frequency (percentage) is shown. Responses were not exclusive, so the total may exceed 100%.
[a]Lack of evidence refers to the statement regarding the insufficient scientific evidence for the effectiveness of simulation education using the technology;
[b]limitation of fidelity and computer teaching refers to the statement regarding the limitations of current computer-based teaching that reserve room for improvement to fully meet the educational needs;
[c]user comfort refers to the statement regarding the negative physiological and/or psychological impact on users;
[d]unclear needs refers to the statement regarding the ambiguity of the educational needs or no demands from learners, e: maintenance needs refers to the statement regarding the constant updates and technical maintenance;
[f]scalability and accessibility refers to the statement regarding the scalability for a large number of learners, g: degree of customization refers to the statement regarding the flexibility of software and variety of content of the technology;
[h]cost refers to the statement concerning the price of and budget constraints for new implementation and management of the technology;
[i]IT support and dedicating staff refers to the statement regarding the availability of human resources for maintenance and actual implementation of the technology;
[j]rapidly developing market refers to the statement regarding the fear that technology may quickly become obsolete amid the constant development and improvement.

Discussion

This survey demonstrates the availability and utilization of XRs in Canadian simulation centres as well as the attitudes of directors towards these technologies. Along with its novelty and the high response rate, our study also has the notable strength of highlighting differences in respondents' perceptions of the various types of XRs. A benefit of our study is that XR technologies are often considered or treated as a collective whole, which leads to confusion in understanding key differences.[16] Relatedly, we provided clear definitions in the survey to encourage respondents to differentiate one technology from others.

As a result, we found variability in the patterns of deployment and directors' and representatives' perspectives among five XR technologies. For instance, the survey results showed a lower rate of purchase/ownership/lease of Immersive AR and a higher rate of use of Immersive VR environments in research than education. In addition, the degree of motivation for future use of these two XR technologies was higher compared to other types of XR. These findings may suggest that simulation centres are taking a more careful approach to adopting these relatively new XRs requiring additional hardware, due to the yet uncertain cost-benefit. Respondents highlighted cost and lack of evidence as barriers to future adoption.

The degree of satisfaction tended to be only moderate across XR types, which may reflect substantial barriers and room for improvement in XR use. Experienced and foreseen challenges reported by directors provide informative suggestions to various stakeholders, peer directors, faculty, and technology developers, for future technology deployment, development, and implementation. For example, technology-specific barriers, such as computer teaching limitations, flexibility of the software, and user comfort, may be addressed by constant technological evolution; feedback to technology developers and vendors is encouraged to promote technological improvement.

Respondents highlighted issues related to human and financial resources reported in previous studies on simulation centre needs.[8,9,17,18] Building standards among simulation centres for technology use such as having a dedicated IT person for maintenance of XRs may be necessary to advance the technology use in simulation centres. Improving compatibility among software and devices and providing long-term support from industry XR providers may also be helpful in accommodating the limited resources of simulation centres.

Survey results also pointed to the importance of evidence and needs assessment when simulation centre directors make decisions on the deployment of XRs. Actively sharing research results on XR use in simulation education with other simulation centre directors, faculty members, learners, and researchers is crucial to filling gaps in evidence and needs assessment to build collective knowledge and community to best use XRs in Canadian simulation education. Some directors doubted the value of XRs at simulation centres, especially Screen-based Virtual Worlds and Non-immersive Augmented Reality, because these technologies do not necessarily require simulation centre facilities as learning environments.[19,20] Simulation centre directors and faculty should carefully select technologies and modalities for simulation based on needs, learning objectives, learner group type, and cost effectiveness.

We used the Checklist (CHERRIES; see Appendix A) to describe and justify our survey development. Future research may collect and analyze evidence of validity from a larger scale study (e.g., international), but we prioritized keeping the survey short to maximize participant rate rather than to add questions that might provide validity evidence, such as repeating items to look for response patterns or interviewing simulation centre directors to review how they understood the items. Providing definitions for the technologies we asked them about was, however, a measure we took to help ensure validity in the context of a short and low-stakes survey.

This study had some limitations. The authors conducted a national survey amongst the RCPSC accredited Canadian simulation centres, and the results may not reflect all Canadian or international simulation centres. Future studies should include a broader range of simulation centres to enhance the generalizability of the findings. Further, because of the pace of technological change results may differ at a later date, as is often the case with studies on XR and similar technologies.

Conclusions

In conclusion, this study provides an overview of the current availabilities of XRs in RCPSC-accredited Canadian simulation centres and directors' perspectives toward these technologies. The patterns of use, the degree of satisfaction, and challenges varied depending on the types of XR. Addressing the gaps between the current XR capabilities and directors' expectations is essential to enhance XR integration into simulation-based education.

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Appendices

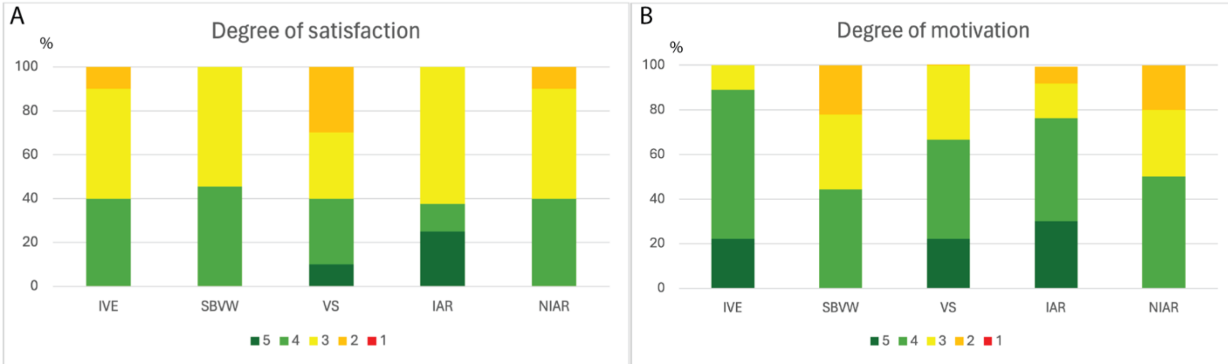
Appendix A. Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	Explanation	*Page Number, Comment*
Describe survey design	Describe the target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	*Page 1 (Title page) and 8 (Methods)* *Target population was directors from all 23 Royal-College Accredited simulation centres.*
IRB approval	Mention whether the study has been approved by an IRB.	*Page 7 (Methods)* *The Institutional Review Board at McGill University approved this study protocol (A06-E27-23B (23-04-060)).*
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	*We stated "Authors sent the initial invitation by email including a survey link and informed consent to directors and representatives from the 23 simulation centres" on Page 7 (Methods). The informed consent included information on the length of the survey, the investigators, the purpose of the study, and what kind of data, where and how long data would be stored.*
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	*Only email addresses were collected as personal information. As with other responses obtained from the survey, data was stored electronically in a secure, institutional cloud-based database that is accessible only to the investigators.*
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	*We described how the survey was developed on Pages 5-7. The electronic survey was repeatedly tested by the study team and volunteers.*
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	*This was a closed survey, and we sent the survey to the specific population, directors of Royal-College accredited simulation centres by email with a link to the survey. Passwords were not provided, but we assumed that only the recipients of the invitation and their delegates could access the survey.*
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	*We described that we approached the population by email on Page 8.*
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	*Because the target population was specified, we recruited them only through the email invitation (on Page 8).* *The email is included in the Appendices.*
Web/E-mail	State the type of e-survey (eg, one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	*We described that this was an online survey, using the LimeSurvey (Page 6). The data was automatically captured by the LimeSurvey.*
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a survey about vaccination on an anti-immunization Web site will have different results from a Web survey conducted on a government Web site	*We did not use a website to post the survey because the target audience was specified.* *We only used email to approach the population.*

Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	*Participants filled in the survey on a voluntary basis with an agreement to the informed consent.*
Incentives	Were any incentives offered (eg, monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	*No*
Time/Date	In what timeframe were the data collected?	*We described the timeframe as "responses were collected between July and September 2023" on Page 7.*
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	*Because of the arranged conditional branching, the randomization of question order was not possible.*
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce the number and complexity of the questions.	*We used conditional branching. Branching allowed the survey to be more efficient by limiting response options based on previous answers. For example, when a respondent answers "have used screen-based virtual world," the respondent would not be asked about their motivation for future use of screen-based virtual worlds. This is described on Page 7.*
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	*One question per page was given.*
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	*Approximately 15 pages were given (The number of questions/pages may differ because of conditional branching).*
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if "yes," how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as "not applicable" or "rather not say," and the selection of one response option should be enforced.	*Yes, most of the questions were designated as mandatory questions, and the survey platform, LimeSurvey, could identify missing answers, and automatically remind respondents to complete them before submission.*
Review step	State whether respondents were able to review and change their answers (eg, through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	*There was a function to "go back" by clicking a Back button. Respondents were not able to review and change their responses once submitted.*
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	*Neither IP address nor cookies were saved for this study.*
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	*As the size of population invited to this survey was already known as 23, we would replace this with the response rate.*
Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	*N/A*
Completion rate (Ratio of users who finished the survey/users who agreed to participate)	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that "completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate.")	*Completion rate was 100%. Pending response was resumed and completed by a reminder.*
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the	*No cookies were used.*

	survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	*No IP addresses were saved for this study.*
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	*No*
Registration	In “closed” (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	*A case where one responder completed the survey twice did not occur in this survey. If anyone had tried, IP address tracking would have prevented it.*
Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	*Only completed questionnaires were analyzed. We did not have incomplete response as the pending response was resumed and completed by a reminder.*
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	*N/A*
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	*N/A*

Appendix B. Distribution of degree of satisfaction and motivation



A: Degree of satisfaction with using XRs. Survey questions asked about the degree of agreement with the statement "I am satisfied with [each XR]" using 5-point Likert scale, where 1 means strongly disagree, 3 means neither agree nor disagree, and 5 means strongly agree. B: Degree of motivation for future use of XRs. Survey questions asked about the degree of agreement to the statement "I would like to use [each XR] at my simulation centre." using 5-point Likert scale, where 1 means strongly disagree, 3 means neither agree nor disagree, and 5 means strongly agree. IVE, immersive virtual reality; SBVW, screen-based virtual world; VS, virtual simulator; IAR, immersive augmented reality; NIAR, non-immersive augmented reality.

Appendix C. Invitation email

Dear Dr. ,

We are conducting a study to identify the status of virtual reality (VR) and augmented reality (AR) technologies in medical education in simulation centres across Canada. This study has received ethics approval from the Faculty of Medicine and Health Sciences at McGill University (A06-E27-23B (23-04-060)).

You are invited to participate in this survey study based on your position with a Canadian RCPSC-accredited simulation centre. By participating in this study, you will be asked to complete a survey. The survey should take approximately 5 minutes to complete. Here is the link to the survey: [survey link was inserted].

We anticipated that the results of this study would identify challenges and unmet needs. In addition, the identified experiences and perceptions in this study are expected to help simulation centre directors and staff make decisions on future technology acquisition and deployment at other institutions. Further, findings from this study may encourage industry and developers to reflect on current technologies and modalities and to provide a new technology and modality.

Your input is greatly appreciated. For further information or if you have any questions, please contact the co-investigator and study coordinator, [first author], at [email address], or PI, [corresponding author], at [email address].

Sincerely,