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Original Article

Short Survey on Cardiopulmonary Resuscitation and Automated External Defibrillator Training in Rural British Columbia Schools: Preliminary Findings and Hypothesis-Generating Insights

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ABSTRACT

Background: British Columbia (BC) faces more than 7000 out-of-hospital cardiac arrests annually, which disproportionately affect rural areas, owing to their slower emergency medical service response and limited specialized care. Despite the known benefits of automated external defibrillator (AED) access and cardiopulmonary resuscitation (CPR) training, their status in rural BC schools is poorly documented.

Methods: We used an online survey of principals and vice-principals of rural schools in BC. The survey assessed AED accessibility, prevalence of CPR and AED training, and obstacles to implementing such training. Questions covered school demographics, AED installation, and CPR and/or AED training for staff and students.

RÉSUMÉ

Contexte : La Colombie-Britannique (C.-B.) est confrontée chaque année à plus de 7 000 arrêts cardiaques extrahospitaliers, qui touchent de manière disproportionnée les zones rurales, en raison de la lenteur de l'intervention des services médicaux d'urgence et de l'insuffisance des soins spécialisés. Malgré les avantages connus de l'accès aux défibrillateurs externes automatisés (DEA) et de la formation à la réanimation cardio respiratoire (RCR), leur statut dans les écoles rurales de la C.-B. est peu documenté.

Méthodes : Nous avons utilisé une enquête en ligne auprès des directeurs et des directeurs adjoints des écoles rurales de la C.-B. L'enquête a évalué l'accessibilité des DEA, la prévalence de la

Annually, British Columbia (BC) experiences over 7000 out-of-hospital cardiac arrests (OHCAs), which accounts for ~12% of Canada's cardiac-arrest incidents.[1-3] In BC, 19% of all cardiac-arrest events occur in rural areas, where 12.7% of the population is located.[4] Although the urban regions of Fraser and Vancouver Coastal Health report a substantial number of OHCAs, with an incidence rate of 126 per 100,000, the more-rural health authorities, including Northern, Interior, and Island Health, experience higher rates. Specifically, the Interior has a rate of 153 per 100,000; the Vancouver Island region has a rate of 165 per 100,000; and the Northern region has a rate of 177 per 100,000.[1,5,6] Overall, the crude incidence of OHCA in BC is approximately 138 per 100,000 population.[1] Rural communities experience disparities in OHCA treatment, compared to that for their urban counterparts.[7-10] Notable disparities exist between urban and rural areas in the effectiveness of resuscitation efforts for OHCAs. These disparities arise from several factors—the limited availability of first responders trained to perform immediate cardiopulmonary resuscitation (CPR), reduced accessibility to automated external defibrillators (AEDs), variable emergency medical services response times, and greater distances to hospitals capable of providing specialized postresuscitation care.[7,10,11] These findings underscore the need for tailored interventions to reduce these geographic disparities and improve OHCA outcomes.

In rural BC, healthcare resource disparities and poor cardiac OHCA outcomes present significant challenges. The BC Centre for Disease Control (BCCDC) notes that many communities across the province are located far from primary

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Results: We recruited 23 elementary schools (kindergarten-grade 7; 46%), 6 middle schools (grades 6-8; 12%), and 21 high schools (grades 8- 12; 42%). A total of 72% (36 of 50) had at least one AED installed; 46% required staff CPR training; and 24% provided student CPR training. Significant gaps in training were noted for elementary and middle school students, compared to the training for high schools ($P < 0.05$).

Conclusions: Disparities in AED and CPR training across rural schools in BC exist, highlighting a need for policy improvements and innovative solutions to enhance first-aid education. Barriers to implementing CPR and AED training included lack of funding, curricular priority, time constraints, and limited resources. Despite a 10.3% response rate, this study reveals significant disparities in AED and CPR training across school levels in rural BC, underscoring the need for targeted policies and educational strategies to enhance emergency preparedness and improve cardiac arrest outcomes in underserved areas.

Résultats : Nous avons recruté 23 écoles primaires (de la maternelle à la septième année; 46 %), 6 écoles intermédiaires (de la sixième à la huitième année; 12 %) et 21 écoles secondaires (de la huitième à la douzième année; 42 %). Au total, 72 % des écoles (36 sur 50) disposaient d'au moins un DEA, 46 % exigeaient une formation en RCR pour le personnel et 24 % une formation en RCR pour les élèves. Des lacunes significatives dans la formation ont été constatées pour les élèves des écoles primaires et intermédiaires, par rapport à la formation dispensée dans les écoles secondaires ($p < 0,05$).

Conclusions : Il existe des disparités dans la formation DEA et RCR dans les écoles rurales de la C.-B., ce qui souligne la nécessité d'améliorer les politiques et de trouver des solutions novatrices pour renforcer la formation aux premiers secours. Les obstacles à la mise en œuvre de la formation en RCR et DEA comprenaient le manque de financement, la priorité des programmes, les contraintes de temps et les ressources limitées. Malgré un taux de réponse de 10,3 %, cette étude révèle d'importantes disparités dans la formation DEA et RCR dans les écoles rurales de la C.-B., soulignant la nécessité de politiques ciblées et de stratégies éducatives pour renforcer la préparation aux situations d'urgence et améliorer les résultats en matière d'arrêt cardiaque dans les régions mal desservies.

health centres, making it harder to access emergency healthcare.[5] These challenges are exacerbated further in rural settings, owing to a lower population density, a rapidly aging demographic, with a higher proportion of seniors compared to that in urban areas, and increased distances from healthcare resources.[12] A critical barrier identified is the lack of readily available services for delivery of appropriate and timely diagnostics and treatment, which contributes to these health disparities.

Given that a significant proportion of OHCAs occur near schools (11.1%-60.9%), equipping these institutions with AEDs, and training school-aged children in their use, can improve survival outcomes.[13,14] Countries with mandatory CPR education in schools report significantly higher rates of CPR performed by bystanders, and improved survival rates following OHCAs.[15-17] In countries in which educating schoolchildren in CPR is mandatory, bystander CPR is performed in 60%-75% of cases, and the survival rate after OHCA can be tripled.[15] European countries, and US states with such mandates, have higher rates of CPR performed by bystanders.[15,18-20] Schoolchildren—for whom cardiac arrest is often witnessed in a family member, are more motivated to perform basic life support (BLS).[21-23] Mandatory CPR and AED training for schoolchildren results in a prepared population that can respond effectively in emergencies, thereby improving bystander CPR rates and reaching the entire population.[17-19,24,25]

Adoption of CPR and AED training in BC schools could bridge the OHCA outcome gap between rural and urban areas. Providing BLS training and AEDs in schools are cost-effective solutions to improve survival outcomes.[18,26] Prompt delivery of CPR and use of an AED are critical in cardiac emergencies; both significantly enhance the chances of survival and recovery.[27,28] Early defibrillation performed within the first few minutes of cardiac arrest dramatically improves outcomes, with minimal neurologic impact.[29]

CPR training and the presence of AEDs are not mandated in BC elementary or high schools, although both are recommended by the Heart and Stroke Foundation of Canada.[30,31] In Ontario high schools, only 18.8% of the schools provided BLS training, owing to funding, time, and resource constraints.[9] How schools implement BLS training programs is left to the discretion of each school board. Given the lack of contemporary data on how many rural BC schools offer this training, we aimed to evaluate the availability of AEDs, the current rates of CPR and AED training in publicly funded rural BC elementary, middle, and high schools, and the barriers to implementing CPR and AED training for BC staff and students.

Materials and Methods

Study design

A qualitative study was conducted between April 18 and July 6, 2023, using an online survey of rural school principals or vice-principals. Our team selected the definition of a rural community on the basis of criteria established by the Joint Standing Committee on Rural Issues (JSC). This organization, representing the provincial government and doctors of BC, has developed a comprehensive list of communities under the Rural Practice Subsidiary Agreement (RSA). The RSA is designed to improve patient care and the availability of physician services in rural and remote areas of BC, focusing on the unique and challenging clinical circumstances faced by rural physicians.[32,33]

The study population included all publicly funded rural BC schools in communities covered by the RSA. As of 2023,

this group consisted of 482 rural schools—112 elementary schools, 179 middle schools, and 191 high schools, administered by 43 school districts.

Survey design

The survey (Supplemental Appendix S1), designed electronically via the University of BC (UBC) survey tool on Qualtrics (Qualtrics, Provo, UT), drew inspiration from a preceding study by Allan et al. evaluating CPR and AED training in Ontario schools.[9] This survey comprised 21 open- and closed-ended questions, targeted specifically to principals and vice-principals, and was modified to better align with the context of the BC school system. Questions were organized into 4 sections, as follows: school demographics, AED installation and maintenance, CPR and AED training for staff, and similar training for students. Additionally, for schools that lacked AEDs, or those that did not provide CPR and AED training to their staff or students, the survey included questions designed to identify and explain the obstacles preventing the installation of AEDs or the facilitation of CPR training programs. Elementary, middle, and high schools were compared, to identify any significant differences in AED installation, as well as CPR and AED training for staff and students, across these school levels. An understanding of these differences is crucial for developing targeted interventions and policies to improve cardiac emergency preparedness in rural schools.

Survey implementation

Three investigators (W.C. T. N., and A.K.) distributed the survey by directly e-mailing school principal and vice-principal contacts on the BC School & District Contact Information Web site. Researchers then followed up via phone call if participants had not yet responded to the initial e-mail to confirm whether or not they were choosing to participate. Participants were offered CAD$5 coffee gift cards of their choice for their participation. This project received approval from the University of BC Behavioral Research Ethics Board (BREB; Project Certificate H16-00044).

Statistical analysis

Descriptive statistics were used to analyze close-ended questions, whereas thematic analysis and grouping were used to analyze open-ended questions. Quantitative analyses aimed to compare elementary, middle, and high schools in regard to AED installation, CPR and AED training for staff, and similar training for students. Categorical variables were presented as counts or percentages and were analyzed using χ^2 or the Freeman-Halton extension of the Fisher exact probability test,[34] as appropriate. Continuous variables are presented as means $\pm$ standard deviations, or as medians $\pm$ interquartile ranges, and were analyzed using 1-way analysis of variance or the Kruskal-Wallis test, as appropriate. A P value < 0.05 was considered significant. Except for the Fisher exact test, statistical analyses were performed using Prism, version 9.4.1 (GraphPad, La Jolla, CA).

Results

Demographics and study population

We surveyed 484 schools in rural BC, achieving a response rate of 10.3% (50 of 484). Of the 50 schools that responded, 23 (46.0%) were elementary schools (kindergarten-grade 7), 21 (42.0%) were high schools (grades 8-12), and 6 (12.0%) were middle schools (grades 6-8; Fig. 1; Table 1). The mean ($\pm$ standard deviation) number of students per school was 315 ($\pm$ 100). The majority of elementary schools (60.8%) and high schools (52.4%) had $\leq$ 25 staff members, whereas the majority (66.7%) of middle schools had 26-75 staff members. Altogether, our survey reached 50 schools, representing 12,807 students in rural BC.

AED installation and training

A total of 36 schools (72.0%) had at least 1 AED installed (Table 2). Notably, only 11 elementary schools (47.8%) had an AED, compared to 100% and 90.5% of middle and high schools, respectively ($P < 0.05$). Of the schools that had AEDs installed, only 2 (10.5%), both high schools, had 2 AEDs installed. Staff AED training was provided as part of CPR education for most schools (71.4%), most commonly by a professional association (eg, the Red Cross). Most schools without AEDs suggested that this lack was the result of barriers, such as funding shortages or the prohibitive cost of AEDs (53.8%), and a lack of district policy mandating the presence of AEDs (30.8%). A few schools (15.4%) reported that AEDs were accessible in adjacent buildings or nearby locations (eg, a nearby ambulance station), whereas others suggested that

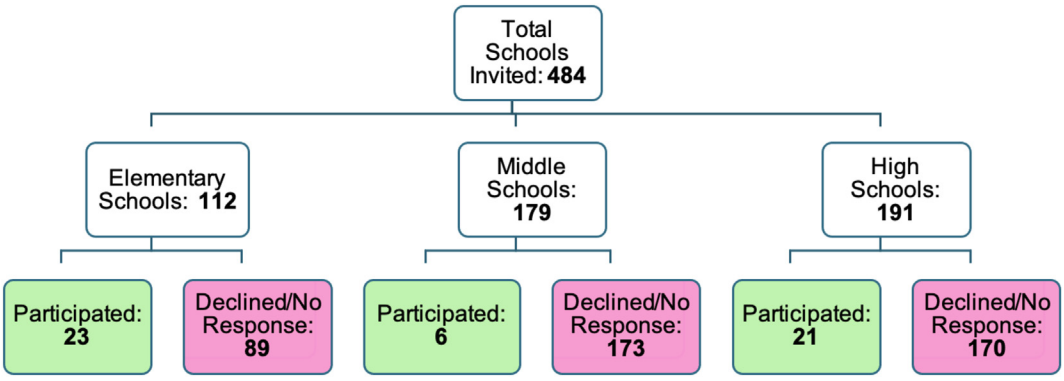

Figure 1. Survey participation among 484 schools in rural British Columbia, categorized by school type.

Table 1. School demographics (British Columbia)

Variable	Elementary schools	Middle schools	High schools	Total
Schools	23 (46.0)	6 (12.0)	21 (42.0)	50
Students per school	200 ± 120	363 ± 252	381 ± 418	315 ± 100
Staff members per school				
0–25	14 (60.8)	2 (33.3)	11 (52.4)	27 (54.0)
26–75	9 (39.1)	4 (66.7)	7 (33.3)	20 (40.0)
76–100	0	0	1 (4.8)	1 (2.0)
101–125	0	0	2 (9.5)	2 (4.0)

Values are n (%) or mean ± standard deviation.

awareness was lacking regarding AED importance or a lack of prioritization by the curriculum (7.7%; Fig. 2A).

CPR training

Staff CPR training was a requirement in 23 schools (46%; Table 3). Most elementary schools (56.5%) required staff training, compared to 33.3% of middle schools and 38.1% of high schools. As with AED training, CPR training was most commonly (in 74.2% of cases) conducted by a professional association. The duration of training, when it was specified (unspecified in 50.0% of cases), was most commonly 1 day (in 43.8% of cases). CPR training was provided to students in 13.0% of elementary schools, 42.9% of high schools, and no middle schools ($P < 0.05$). As for AEDs, funding was the most commonly reported barrier to the provision of staff CPR training (32.0%). Other barriers to provision of staff training included time and availability (20.0%), lack of interest from staff for voluntary training (16.0%), and geographic inaccessibility to training sites (12.0%; Fig. 2B). Meanwhile, reported limitations to student CPR training included lack of curricular priority (ie, training not being mandated by BC curriculum; 13.2%), a shortage of CPR-trained staff (15.8%), and a perceived lack of relevance for younger (eg, elementary-aged) children (20.0% of elementary schools; Fig. 2C). Notably, some principals expressed an interest in and an intention to offer first-aid training.

Discussion

This study demonstrates that although many rural BC schools have AEDs installed and offer some level of CPR training, inconsistencies and gaps remain in the availability and quality of CPR and AED training. Survival rates for OHCAs are notably low, especially in rural and remote areas.[7] Data from Nova Scotia showed that patients in urban centres were 107% more likely to survive to hospital discharge than those in rural areas.[7] Urban patients also benefited from a quicker mean time to defibrillation of shockable rhythms—11.2 minutes, compared to 17.5 minutes in rural areas. Furthermore, studies indicate that the likelihood of return of spontaneous circulation at hospital arrival, as well as survival to hospital discharge, at 30 days and at 1 year, is significantly lower in rural than in urban locations.[35,36] Enhancement of CPR training and an increase in the availability of AEDs are crucial measures to improve survival outcomes for individuals experiencing cardiac arrest. Although first-aid training is offered in grade-11 physical education programs in BC, the law does not require the installation of AEDs in schools.[30,37] Additionally, enrollment in a grade-11 physical education course is not mandatory for students in BC.

Table 2. Automated external defibrillator (AED) installation and training.

Variable	Elementary schools	Middle schools	High schools	Total	*P*
AED installed	11 (47.8)	6 (100.0)	19 (90.5)	36 (72.0)	0.0019
AEDs per school					
1	11 (100.0)	6 (100.0)	17 (89.5)	34 (94.4)	NS
2	0	0	2 (10.5)	2 (5.6)	NS
AED location					
Main office/hallway	4 (36.4)	2 (33.3)	4 (21.1)	8 (22.2)	NS
Front entrance/foyer	2 (18.2)	3 (50.0)	5 (26.3)	10 (27.8)	NS
Gym	0	1 (16.7)	3 (15.8)	4 (11.1)	NS
Cafeteria	0	0	0	0	NS
Other	2 (18.2)	1 (16.7)	1 (5.3)	5 (13.9)	NS
Unspecified location	3 (27.3)	0	6 (31.6)	9 (25.0)	NS
Policy for AED maintenance	7 (63.6)	6 (100.0)	14 (73.7)	27 (75.0)	NS
AED training is a part of CPR	12 (63.2)	5 (83.3)	13 (76.5)	30 (71.4)	NS
Type of AED trainers					
Local EMS	0	0	0	0	NS
Professional association*	5 (26.3)	4 (66.7)	1 (5.9)	10 (23.8)	NS
Staff trainers	0	0	0	0	NS
Private company	0	0	0	0	NS
Unspecified format	8 (42.1)	1 (16.7)	11 (64.7)	20 (47.6)	NS
Unsure	1 (5.2)	0	2 (11.8)	3 (7.1)	NS
Length of AED training					
< 1 h	2 (14.3)	0	0	2 (6.1)	NS
1–2 h	1 (7.1)	0	1 (7.1)	2 (6.1)	NS
1/2 d	0	0	0	0	NS
1 d	0	0	4 (28.6)	4 (12.1)	NS
2 d	1 (7.1)	0	0	1 (3.0)	NS
Unspecified	10 (71.4)	5 (100.0)	9 (64.3)	24 (72.7)	NS

Values are n (%), unless otherwise indicated.

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; NS, not significant.

*Includes the Red Cross, the Heart and Stroke Foundation of Canada, and St. John's Ambulance.

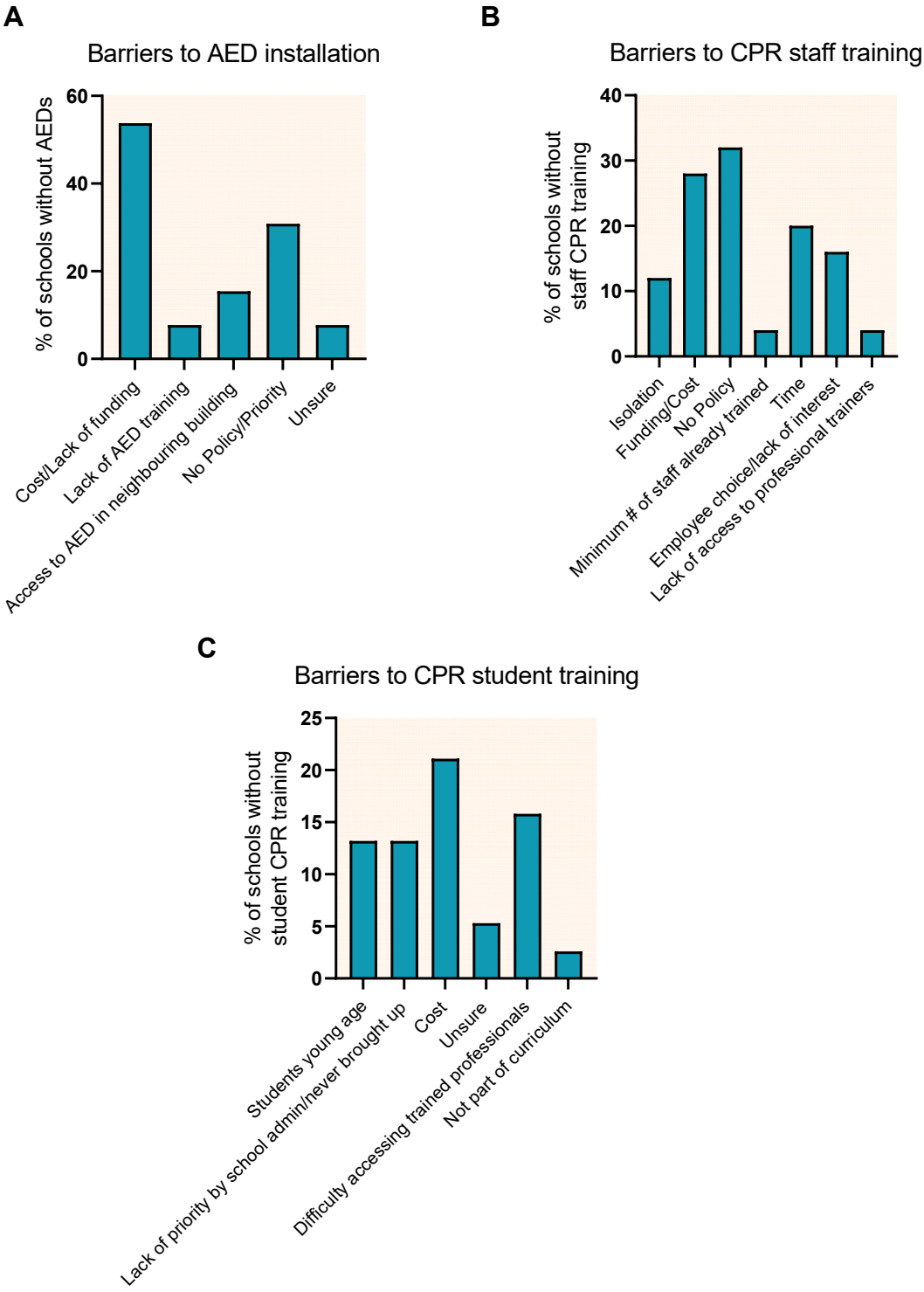

Figure 2. Reported barriers to automated external defibrillator (AED) installation and first-aid training. Barriers to (**A**) AED installation, (**B**) cardiopulmonary resuscitation (CPR) staff training, and (**C**) CPR student training. Data represent frequency of each reported barrier of the respondent schools without an AED or CPR training. admin, administration.

Current state of AED and CPR training

Our findings indicate that most elementary schools did not have an AED installed, whereas most middle schools and high schools did. Specifically, our results show that only 47.8% of elementary schools have AEDs installed, compared to 100% of middle schools and 90.5% of high schools. Moreover, only 13.0% of elementary schools, 42.9% of high schools, and no middle schools offer CPR training to

Table 3. Cardiopulmonary resuscitation (CPR) training

Variable*	Elementary schools	Middle schools	High schools	Total	*P*
Staff training					
Staff members required to have CPR training	13 (56.5)	2 (33.3)	8 (38.1)	23 (46.0)	NS
Staff members trained per school	2 (2, 3)	2 (1.5, 2)	3.5 (2.6, 4)	2.25 (2, 3.75)	NS
Type of trainers					
Local EMS	0	0	1 (9.1)	1 (3.2)	NS
Professional association*	10 (66.7)	5 (100.0)	8 (72.7)	23 (74.2)	NS
Staff trainers	0	0	0	0	NS
Private company	0	0	1 (9.1)	1 (3.2)	NS
Unspecified format	3 (20.0)	0	0	3 (9.7)	NS
Unsure	2 (13.3)	0	1 (9.1)	3 (9.7)	NS
Length of training					
1–60 min	1 (6.3)	0	0	1 (3.1)	NS
1/2 d	0	0	1 (8.3)	1 (3.1)	NS
1 d	9 (56.3)	1 (20.0)	4 (33.3)	14 (43.8)	NS
$\geq$ 2 days or more	0	0	1 (8.3)	1 (3.1)	NS
Unspecified	6 (37.5)	4 (80.0)	6 (50.0)	16 (50.0)	NS
Student CPR training					
CPR training provided to students	3 (13.0)	0	9 (42.9)	12 (24.0)	0.0258

Values are n (%), or median (interquartile range), unless otherwise indicated.
EMS, emergency medical service; NS, not significant.
*Includes the Red Cross, the Heart and Stroke Foundation of Canada, and St. John's Ambulance.

students. This inconsistency underscores the need for more-uniform training standards and implementations to ensure that all students receive potentially life-saving education. Other studies have found that CPR training rates in schools are low despite government mandates.[9,38,39] In Denmark, even with CPR and AED training in schools being required by legislation since 2005, only 28.4% of eligible classes had completed CPR training, and even fewer (10.3%) had completed AED training.[38] Similarly, in Ontario, AED installations were reported in 59.2% of elementary schools, compared to 76% and 90% of middle and high schools, respectively.[9] This finding suggests that although mandating CPR training is a crucial first step, legislation is often insufficient without additional measures such as community education, the raising of awareness, and frequent assessment of implementation at each school. Moreover, elementary and middle schools offered students significantly less CPR training than did high schools, mirroring what was reported in Ontario. Notably, a higher proportion of elementary teachers are trained in CPR, compared to that among their secondary-school counterparts. However, a remaining concern is that only a small percentage of students receive CPR training, underscoring a critical gap in current educational safety protocols. Our study found that staff training is required in only 46% of cases, lower than the 60% reported in Ontario.

Similar barriers were noted in both provinces, including perceived misconceptions, lack of policy or mandate, and limited resources. Notably, our research highlights a more pronounced shortage of CPR-trained personnel in rural BC (15.8%), compared to that in Ontario (8.2%),[9] a discrepancy likely exacerbated by the challenges of geographic accessibility. These findings suggest that we must advocate for a comprehensive approach to ensuring equitable access to AED and CPR training, considering geographic disparities alongside the necessity for adequate funding and increased awareness. The parallels drawn here spotlight rural BC's specific challenges and reflect a broader pattern of uneven access to CPR and AED education across various regions.[40]

Strategies to implement CPR education in schools, and future directions

One reason reported by principals for the lack of CPR and AED training is reliance on local paramedics. BC paramedics are well equipped to initiate high-quality resuscitation and advanced life support procedures. However, rural communities face staff shortages and geographic barriers, leading to longer response times and lower survival rates.[41,42] External factors, such as extreme-heat events, compound these challenges, further impacting OHCA survival rates in BC.[43]

An important strategy to increase the survival rate of those who experience OHCA is to educate schoolchildren. Hence, provision of annual BLS training in schools for all children starting from age 4 years, to enhance their readiness to perform CPR, has been suggested,[26] We recommend including CPR and AED training in specific grades—notably, grades 5, 8, and 10. These grades, respectively, represent grades from elementary school, middle school, and high school. A grade-10 level of physical education is currently a graduation requirement for all BC high school students. Including training within this course will ensure that all graduates are equipped with this life-saving skill.

Although legislation alone is insufficient, promising results have been observed with innovative CPR training methods for young schoolchildren, including training by medical students, self-training using self-instruction kits, and peer training, all of which compare favourably to traditional instructor-led training.[9,44] Leveraging technology and innovative teaching methods may help overcome some of the logistical challenges associated with delivering CPR and AED training in rural areas. For instance, virtual training modules, mobile training units, and partnerships with local emergency services can extend the reach of training programs and make them more accessible to remote communities. Additionally, efforts should be made to

increase awareness and advocacy around the importance of CPR and AED training within rural communities. Collaborative initiatives undertaken through the Advanced Coronary Treatment Foundation are examples of such efforts. Repetition of training on a recurrent basis is also important to help trainess retain the skills learned.[20] Ultimately, the involvement of schools, healthcare workers, community organizations, and policymakers can help raise awareness, secure funding, and provide resources to support training programs.

Limitations

The study's response rate, standing at 10.3% from the surveyed schools, represents a low level of participation that may not adequately reflect the full spectrum of CPR and AED training practices across rural BC. This low response rate introduces a high risk of bias and limits the external validity of our findings, thereby impacting the extent to which they can represent the diverse challenges and strategies employed by all rural schools in the province. The potential exists for participants to not fully adhere to survey guidelines, which could affect data accuracy and consistency. Recall bias may also influence responses, as participants might not remember past CPR and AED training events accurately. Additionally, offering compensation introduces economic bias, with a possible effect on the responses given. Furthermore, the unique obstacles posed by geographic isolation in different rural areas might limit the generalizability of our results. The lack of comparative data from urban schools within BC further limits our ability to place the findings within a broader context of provincial disparities in education and healthcare access.

Conclusion

Significant disparities exist in AED installation and student CPR training, with inconsistent implementation across rural BC schools. Frequently reported barriers to implementing this training include lack of funding, lack of curricular priority, time constraints, and limited resources. Strategies to overcome barriers include leveraging technology for virtual training, increasing community awareness, and fostering collaborative initiatives. Our study provides valuable preliminary insights into the current state of CPR and AED training in rural BC schools. These findings are vital for informing future public-health policies and optimizing cardiovascular emergency responsiveness in rural educational settings. To build on these insights, further research should aim to enhance scientific rigor, by utilizing larger sample sizes and addressing potential biases. A more comprehensive and methodologically robust study will further inform effective strategies to improve OHCA outcomes across both rural and urban settings, thereby elevating the standard of cardiac care and preparedness in underserved areas.

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Ethics Statement

The Research Ethics Board at the University of British Columbia Faculty of Medicine approved this study (H16-00044).

Patient Consent

Before participation in this project, respondents read a study description and provided consent.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2024.07.006.