

## Original Article

# The AED Project: Multiorganization Collaboration to Streamline Automatic External Defibrillator Data in Out-of-Hospital Cardiac Arrests

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## ABSTRACT

**Background:** In patients with out-of-hospital cardiac arrest (OHCA), automated external defibrillator (AED) devices contain valuable data about the patient's initial rhythm. The retrieval process was previously without protocol, despite its critical role in the patient journey.

**Methods:** Through a Plan-Do-Study-Act model, the cardiology department at Royal Jubilee Hospital (Victoria, British Columbia, Canada) collaborated with provincial emergency health services (British Columbia Emergency Health Services) to cocreate a request process for data from AEDs used by first responders. British Columbia Fire

## RÉSUMÉ

**Contexte :** Lorsqu'un patient subit un arrêt cardiaque extrahospitalier (ACEH), le défibrillateur externe automatisé (DEA) utilisé par les premiers intervenants contient des données précieuses sur son rythme cardiaque initial. Malgré l'importance de ces données pour le parcours du patient, leur récupération n'était auparavant soumise à aucun protocole.

**Méthodologie :** Dans le cadre d'une initiative fondée sur le modèle Planifier, Développer, Contrôler, Ajuster, le service de cardiologie de l'hôpital Royal Jubilee (Victoria, Colombie-Britannique, Canada) a

More than 166,000 out-of-hospital cardiac arrests (OHCAs) occur in the United States annually,<sup>1</sup> with an estimate of 55 cases per 100,000 worldwide.<sup>2</sup> Patients who have survived an OHCA are at elevated risk (> 40%) of having a recurrent episode of ventricular tachycardia or ventricular fibrillation (VF) in the next 2 years,<sup>3</sup> and have a high rate of mortality within 90 days.<sup>4</sup> VF and ventricular tachycardia together account for > 50% of all OHCAs.<sup>5</sup> Thus, when patients who survive OHCA are admitted to hospital, including the Coronary Intensive Care Unit (CICU), it is imperative to obtain as much information as possible to inform their care, support their recovery, and institute timely secondary prevention therapies.

Multiple studies have shown that the rapid use of automated external defibrillators (AEDs) improves survival from cardiac arrest.<sup>6</sup> In addition to the survival benefit, AEDs can

also provide clues as to the cause of the arrest. The availability of AEDs has resulted in widespread use in the British Columbia Emergency Health Services (BCEHS), fire departments, and community settings. Obtaining the rhythm strips from an AED provides a snapshot of the initial arrest rhythm and can guide further clinical decision-making.<sup>7-10</sup>

One example of this, from our institution, involved a patient with an idiopathic OHCA with reassuring initial diagnostic testing including echocardiography, cardiac magnetic resonance imaging, and angiography. With no systematic process for timely AED data retrieval, the patient was scheduled for an electrophysiology study when the CICU team ultimately obtained the AED data confirming VF as the initial rhythm. These data replaced the need for the electrophysiology procedure, sparing the patient the potential risks that accompany the study. Further, the information confirmed the clinical need for an implantable cardioverter-defibrillator (ICD) and shortened length of hospital stay. This case contributed to the clinical rationale for the quality improvement initiative.

A systematic approach to retrieving valuable AED data for OHCA survivors is lacking. Without a formal process, there is not an efficient means to acquire initial AED rhythm strips. This delay represents a gap in patient care and timely clinical decision-making. The aim of this single-centre quality

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**Ethics Statement:** Under TCPS 2 (2018), Article 2.5, QI studies and projects are not classified as research and therefore are exempt from institutional research ethics review. As such, this work did not require formal ethical approval at Island Health.

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See page 700 for disclosure information.

Departments, which are under municipal oversight, required an alternate strategy. Educational presentations allowed for feedback and spread. Patients surviving OHCA and transfer to the regional cardiac centre were consecutively enrolled from November 2018 to April 2020. We evaluated the timeliness of AED information retrieval, and tracked the process to admission. A retrospective chart review informed specifics after admission. A survey to the Coronary Intensive Care Unit staff was used to assess clinical utility.

**Results:** Seventy-one consecutive patients were enrolled during the study period. Seven rhythm strips arrived with the patient, thus not affected by the initiative. From the remaining 64 cases, 80% ( $n = 51/64$ ) were received within 48 hours, and 88% ( $n = 45/51$ ) were received within 24 hours with a median of 1 hour. Eighteen Coronary Intensive Care Unit staff completed the survey; 81% reported AED data as “very useful” to clinical decision-making ( $n = 13/16$ ). The AED rhythm strips provided insight into OHCA etiology (100%;  $n = 11/11$ ), supported evidence for diagnoses (100%;  $n = 11/11$ ), and reduced unnecessary testing (64%;  $n = 7/11$ ).

**Conclusions:** Implementing an organized protocol allowed for timely access to AED data, which was directly integrated into clinical decision-making and positively affected hospital stay.

improvement study was to increase the number of AED retrievals for patients with OHCA within 48 hours of admission. This work tracked sources of AEDs when used from BCEHS, fire departments, and community sites. To our knowledge, this is the first work to both acknowledge this issue and to establish an organized protocol for AED data retrievals to the CICU in the event of an OHCA.

## Methods

### Setting

This study was set at Royal Jubilee Hospital, in Victoria, British Columbia, Canada. It is the regional cardiac centre for the Island Health Authority with 1001 admissions in its 8-bed CICU in 2019. The catchment area includes 800,132 residents of Vancouver Island; electrophysiology clinical services are also provided for the 762,124 residents of the Interior Health Authority in British Columbia.<sup>11</sup> Using the ARECCI tool, this was determined to be a quality improvement study and therefore, under Article 2.5 of TCPS2, exempt from formal ethical review. The process at Island Health follows this national policy and uses ARECCI to assist with the determination of this exemption. This project met the requirements and this was confirmed in consultation with Island Health's research ethics office.

travaillé en collaboration avec les services médicaux d'urgence de la province (British Columbia Emergency Health Services) afin de créer un processus de demande des données enregistrées dans les DEA utilisés par les premiers intervenants. Pour les services des incendies de la Colombie-Britannique, qui relèvent des administrations municipales, il a fallu adopter une autre stratégie. Des séances de sensibilisation ont permis de recueillir une rétroaction et de diffuser l'information. Nous avons retenu pour notre étude les cas des patients consécutifs qui ont survécu à un ACEH et ont été transférés à un centre de cardiologie régional entre novembre 2018 et avril 2020. Nous avons évalué le caractère opportun de la récupération des données des DEA et fait le suivi du processus jusqu'à l'admission du patient à l'hôpital. L'examen rétrospectif des dossiers a permis d'obtenir les données recueillies après l'admission. Un sondage a été mené auprès du personnel de l'unité de soins intensifs de cardiologie pour évaluer l'utilité clinique de l'initiative.

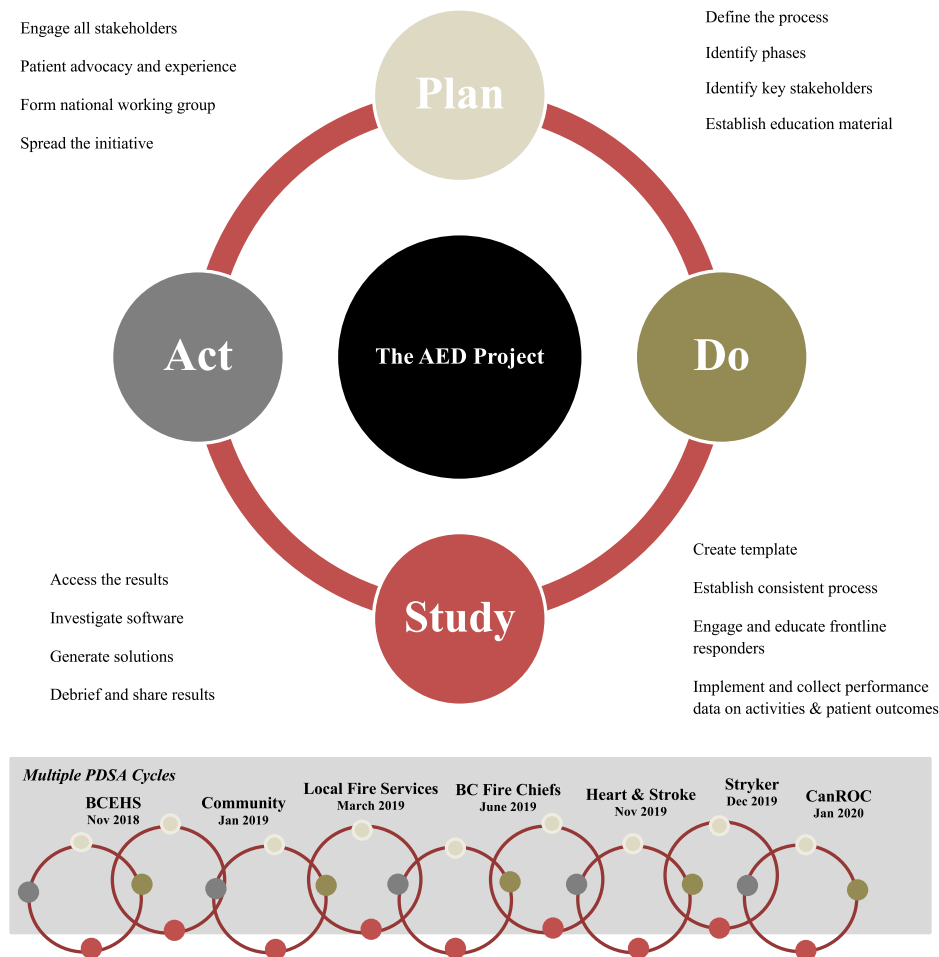
**Résultats :** Au total, 71 patients consécutifs ont été recrutés durant la période de l'étude. Sept patients sont arrivés à l'hôpital avec le tracé de l'enregistrement de leur rythme cardiaque, et n'ont donc pas été touchés par l'initiative. Sur les 64 autres cas, 80 % ( $n = 51/64$ ) des tracés ont été obtenus dans les 48 heures, et 88 % ( $n = 45/51$ ), dans les 24 heures, l'intervalle médian étant de 1 heure. En tout, 18 membres du personnel de l'unité de soins intensifs de cardiologie ont répondu au sondage; 81 % d'entre eux ont dit que les données des DEA étaient « très utiles » à la prise de décisions cliniques ( $n = 13/16$ ). Les tracés du rythme cardiaque produits par les DEA ont permis de mieux comprendre l'étiologie des ACEH (100 %;  $n = 11/11$ ), fourni des données facilitant le diagnostic (100 %;  $n = 11/11$ ) et réduit l'exécution de tests non nécessaires (64 %;  $n = 7/11$ ).

**Conclusions :** La mise en œuvre d'un protocole structuré a permis d'accéder en temps opportun aux données des DEA, qui ont été directement prises en compte dans la prise de décisions cliniques et ont eu un effet positif sur l'hospitalisation.

## Initiative

The project leads followed a Plan-Do-Study-Act (PDSA) action-oriented learning model for health care quality improvement and addressed the initiative in 3 phases.<sup>12</sup> The focus of phase 1 was streamlining AED information with BCEHS; phase 2 was working with fire departments; phase 3 included community and private facilities. The PDSA framework is outlined in Figure 1.

In phase 1, the project lead cardiologist, CICU Clinical Nurse Leader, and Heart Health Quality Lead collaborated with BCEHS representatives to develop a request process for AED downloads for patients who were treated by BCEHS personnel. A small, in-house unpublished retrospective review suggested that half of AED rhythm strips were obtained during admission to the CICU. The aim of this study was to increase this to 80%, and to do so within 48 hours. Dedicated personnel were assigned on a daily basis and a template was created specific to BCEHS for identifying calls. During this time, BCEHS also transitioned to an electronic version of the patient care record including interventions performed, if an AED was used, and the source of the AED. This information can then be included in the patient chart. If the AED was used by responders trained in advanced life support, the information from the AED can be downloaded or printed immediately as part of the admission to hospital. If the AED was used



**Figure 1.** Plan-Do-Study-Act (PDSA) action-oriented framework for this quality improvement initiative. BC, British Columbia; BCEHS, British Columbia Emergency Health Services; CanROC, **C**anadian **R**esuscitation **O**utcomes **C**onsortium.

by a basic life support crew, they download on return to the station and the template is used to notify the BCEHS central site in Vancouver to request the rhythm strips. Thus, the rhythm strips will arrive as a paper-based report with the patient on arrival to the hospital if the OHCA was attended by an advanced life support crew, whereas those that require request from the central download repository will be received as electronic-based rhythm strips from the AED.

In the first PDSA test of change, the Heart Health Quality Lead at Island Health worked closely with BCEHS supervisors to identify gaps within the system. Such gaps included download compliance and engagement for first responders, AED data retrieval from fire departments, and education. The collaborative efforts with BCEHS acted as a feedback mechanism for providing patient outcomes to the crews involved with care.

In phase 2, the role of local fire departments in attending and managing OHCA was elucidated. Unlike the provincially funded and organized BCEHS, British Columbia fire departments are under municipal oversight. Fire departments purchase their own AED and there is no central download to a repository system. As such, an alternate strategy to obtaining AED information from those administered by fire departments was required.

An engagement event in May 2019 involving local fire departments and BCEHS members included an educational presentation on the importance of downloading the AED information and timely relay of that information to hospitals. The success of this event resulted in an invitation to the provincial Fire Chiefs Education Summit in June 2019. This enabled feedback from fire departments and spread of the process provincially. Ongoing feedback to BCEHS and fire department representatives was provided by the Heart Health Quality Lead and allowed for further invitation and spread at educational platforms such as Training in Paradise and the BC Fire Training Officers conference.

### Data collection

Admissions for OHCA survivors were tracked from November 2018 to April 2020 and assessed for timeliness of AED information retrieval, source of the AED, and clinical progress during the admission. The electronic patient care record identified the source of the AED, allowing an e-mail request to be sent for rhythm strip retrieval to the CICU. Initially, these requests were by the Clinical Nurse Leader and Heart Health Quality Lead; however, since then further CICU staff have been trained. Upon manual request, the

available AED rhythm strips were sent directly to the CICU. Rhythm strip adjudication was by the CICU attending and, if needed, a consultant electrophysiologist. A retrospective chart review was completed to inform the details after the hospital admission; this included cardiac investigations and ultimate diagnosis. Finally, members of the Division of Cardiology were asked to complete a confidential and anonymous electronic survey, developed by the QI team. The survey was implemented using and hosted on the Checkbox 2017 Q4 platform (Checkbox Survey Inc, Newton, MA). The intent was to formally assess the initiative as to whether obtaining the AED data were helpful to members of the health care team directly using this information. Questions in the survey queried awareness of the initiative, receipt of AED information, utility, and effect. Further, a free-text portion allowed for respondents to share deidentified cases when use of AED data changed patient outcome or management, if applicable ([Appendix 1](#)).

### Data analysis

Demographic characteristics of patients with OHCA were tabulated using REDCap 10.0.29 (Vanderbilt University Medical Center, Nashville, TN). For quantitative data, summative statistics were calculated using the REDCap platform. Percentage AED retrieval within 48 hours is represented temporally by bar graph. Spread of initiative is represented pictorially and baseline characteristics are represented in table format. Survey response data were tabulated in Checkbox (Checkbox Survey Inc), the approved survey platform for the Island Health Authority, and is represented in table format. Summative statistics were likewise calculated for quantitative responses. The free-text portion was used to supplement anecdotal reports.

## Results

### Cohort characteristics

Seventy-one patients with OHCA survived to hospital admission between November 2018 and April 2020. BCEHS were first on scene 58% of the time ( $n = 41$ ), with fire departments arriving first 34% of the time ( $n = 24$ ). The remaining cases ( $n = 6$ ) were first attended by bystanders and police. Initial rhythms identified included VF (62%;  $n = 44$ ), ventricular tachycardia (14%;  $n = 10$ ), asystole (6%;  $n = 4$ ), and pulseless electrical activity (4%;  $n = 3$ ). Fourteen percent of the strips were determined unknown ( $n = 10$ ); these were the unobtainable rhythm strips explained in the next paragraph. OHCA cases were distributed to multiple community hospitals across Vancouver Island, with select cases transferred from outside of the health authority, representing a large and varied geography ([Supplemental Fig. S1](#)).

### AED data retrieval

Of the 71 cases, 7 (10%) AED rhythm strips arrived with the patient on hospital admission and thus were not affected by the quality improvement initiative. From the remaining 64 cases, 10 were unable to be obtained because of software updates and barriers to accessing public AEDs. Of the retrieved AED rhythm strips, 80% ( $n = 51/64$ ) were received

by the CICU team within 48 hours of request. Because these rhythm strips were obtained through the request process, they were received as electronic-based copies. Specifically, 88% ( $n = 45/51$ ) were received within 24 hours of request with a median time of 1 hour to retrieval during this 24-hour period. The remaining 3 cases were received in  $> 48$  hours from request, with 1 outlier case taking several weeks to obtain. In this particular event, the national police service covering rural areas (Royal Canadian Mounted Police) was first on scene. Barriers were recognized, addressed, and the protocol for AED retrieval was updated to best suit the work flow of this particular site such that future timely retrieval could be achieved. Timeliness of the initiative is showcased temporally in [Figure 2](#).

### Clinical outcomes in the study cohort

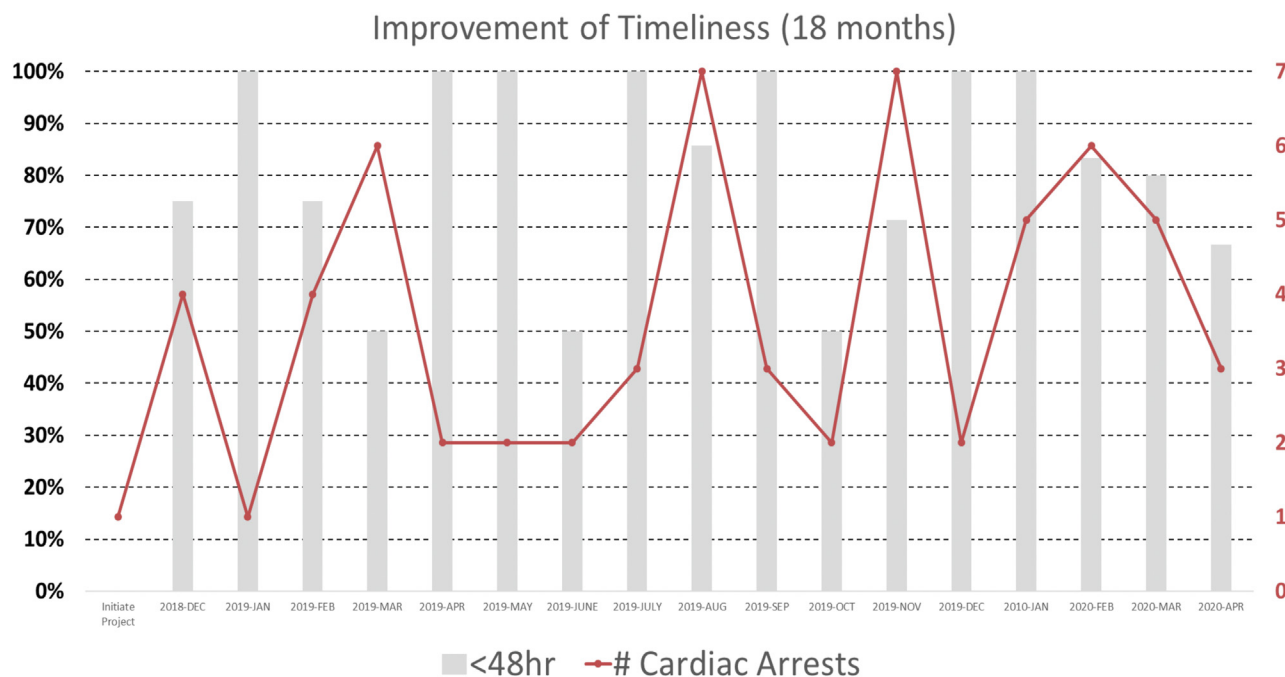
Most patients underwent echocardiogram (97%;  $n = 69/71$ ) as well as catheterization, 49% for diagnostic purposes ( $n = 35/71$ ), and 38% for percutaneous intervention ( $n = 27/71$ ). Nine percent went on to receive a coronary artery bypass graft ( $n = 6$ ). Device therapy included implantation of a pacemaker (1%;  $n = 1/71$ ), ICD (27%;  $n = 19/71$ ), or cardiac resynchronization therapy-defibrillator (CRT-D) (16%;  $n = 11/71$ ). Approximately half of the patients received cardiac magnetic resonance imaging (45%;  $n = 32$ ). Four percent of patients had exercise stress tests ( $n = 3/71$ ) and 6% had electrophysiology studies ( $n = 4/71$ ); no patients in the study cohort underwent electrophysiology drug challenges ([Supplemental Table S1](#)).

### Clinical utility of AED data

Of the 22 cardiologists,  $n = 18$  completed the survey used to evaluate the initiative's utility. Most were aware of a process in place for obtaining AED rhythm strips (75%;  $n = 9/12$ ), with 93% responding that since 2018 they had received AED information while providing care for an OHCA in the Royal Jubilee Hospital CICU ( $n = 13/14$ ). Specifically, a third of respondents reported that they had received AED information for 10 or more patients (33%;  $n = 6/18$ ). The AED information was reported as either useful (19%;  $n = 3/16$ ) or very useful (81%;  $n = 13/16$ ) to inform clinical decision-making. All respondents to this question reported that having the AED information available provided insight into the etiology of the cardiac arrest and supporting evidence for a final diagnosis (100%;  $n = 11/11$ ). Two-thirds of these respondents also reported that unnecessary testing was reduced (64%;  $n = 7/11$ ), 27% reported a reduced length of stay in hospital ( $n = 3/11$ ), and 18% reported that the AED information provided insight into the quality of compressions or resuscitative efforts ( $n = 2/11$ ). In the free-text segment, 3 respondents reported that the AED data provided information that eliminated the need for an ICD. An additional 3 respondents noted that the AED data provided the specific initial rhythm of pulseless electrical activity, which was quoted as "helpful for management" ([Supplemental Table S2](#)).

## Discussion

Community OHCA is common and portends a generally poor prognosis. Despite multiple advancements, OHCA



**Figure 2.** Timeliness of automated external defibrillator retrieval from November 2018 to April 2020.

survival rates have not significantly improved in nearly 3 decades.<sup>13</sup> Thus, when a patient does survive to hospital admission, clinical details of the event have great importance in informing the cardiac care team to best streamline the course of treatment. Before this initiative, the process for AED data retrieval at our institution was ad hoc and time-intensive. Through our quality improvement project, we coordinated with local first responders to develop a systematic protocol for AED data retrieval that was rapid, efficient, and clinically useful.

The value of AED integration into the care of the OHCA patient has long been recognized; early use of AEDs is considered one of the key clinical factors in predicting survival.<sup>13</sup> Further, early defibrillation by bystanders and nontraditional first responders has been appreciated as a potential means to improve survival rates in OHCA.<sup>13-15</sup> For example, dual dispatching of firefighters in addition to emergency medical services was shown to contribute to increased health outcomes of OHCA.<sup>14</sup> In such a setting, personnel from the fire department are often first to arrive on scene; the results of this study reaffirmed this with fire departments arriving before BCEHS one-third of the time. This highlights the importance of involving first responders outside of BCEHS in the AED retrieval process.

As the regional cardiac centre for the Island Health Authority, OHCA patients can be transferred from remote areas and across large distances to reach the Royal Jubilee Hospital (Supplemental Fig. S1). Despite this, distance did not impede the ability for timely retrieval of AED rhythm strips after implementation of the protocol. For example, the AED retrieval time for the Fort St John case was 1 hour, which was the median time to retrieval for the 24-hour period despite occurring 1300 km (800 miles) away.

A systematic approach to obtaining AED information improved timely access. Within a few months of protocol integration, there was noted improvement in the percentage of AED rhythm strips retrieved within 48 hours. The initial aim of receiving 80% of the AED information within this time frame was achieved, with the most rhythm strip retrieval occurring within 24 hours of request.

The positive feedback elicited from the survey responses further solidifies the importance of this initiative. The availability of initial rhythm strips informs the clinical context and allows the health care team to make informed clinical decisions. The CICU physicians indicated that having AED information could reduce length of stay, provide diagnostic certainty, and spare patients from undergoing unnecessary testing or procedures.

There are several limitations to this work. The small survey sample size of 18 limits the capacity of this study to conduct a quantitative assessment. Additionally, respondents not completing the survey in its entirety further decreased the effective sample size and generalizability. Last, although the survey of CICU staff demonstrated subjective perception of changed in-hospital management by means of reduced testing, quantification of these changes in larger-scale studies would be informative. However, with several reports of unnecessary testing that would have been prevented with early evaluation of initial AED rhythm strips,<sup>7-10</sup> the advocacy and need for organized, timely access to this information was consistently shown to be beneficial for diagnostic clarity in an arrested patient and should remain part of the patient chart. Future work entails more rigorous formal assessment of perceived and objective clinical effectiveness of this initiative.

Other cardiac sites in British Columbia are creating similar pathways after learning from this project's experiences. The



success of this initiative was contingent on collaboration and creating a relationship with local BCEHS and fire departments. Understanding the local culture and clarifying the rationale for the project assisted in the collaboration process; through exemplar cases, first responders understood the patient care implications downstream of receiving AED information. In terms of generalizability across provinces, the presence of multiple private ambulance services available in the area might present challenges in obtaining the AED information compared with 1 central ambulance service for the entire region as is present in British Columbia.

### Next steps

Phase 3 of this project is currently ongoing. What remains elusive is getting AED information from public or privately owned AEDs. There are > 10 vendors and no universal method of downloading the information. Unlike BCEHS AEDs, there is no central repository centre to which the AED information can be downloaded and then retrieved. Our project leads are engaging with local groups to develop a process in the event of an OHCA. Further work is ongoing with the local Heart and Stroke Foundation to advocate for a universal download process with the **Public Access Defibrillation (PAD)** program to the BCEHS database. Such collaboration with the Heart and Stroke Foundation is addressing the barriers to accessing public AEDs, including privacy, borrowing of the devices, and education. Connections have been formed with one of the AED vendors supplying AEDs for BCEHS and local fire departments, as well as with the local leads for the newly formed **Canadian Resuscitation Outcomes Consortium (CanROC)** for the spread of the project.

### Conclusion

The AED project shows that effective multiorganization collaboration can improve the capacity for health care teams to make informed decisions on patient care. Through timely access to AED data, details from the time of OHCA can have direct integration into clinical decision-making. This holds the potential to spare patients from the risk of complications of unnecessary procedures, decrease workload burden of health care staff, and for proper utilization of hospital resources.

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### Disclosures

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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.2020.12.023>.

**Appendix 1. Survey questions administered to CICU staff regarding the utility of the AED Project**

Survey question	Question type
Did you know that there is a process for obtaining AED rhythm strips from the pre-hospital setting?	Categorical
Since 2018, have you received AED information while providing care for an OHCA at RJH CCU?	Categorical
Do you believe that an initial rhythm strip would change management for an OHCA?	Categorical
Roughly how many patients have you received AED data for?	Numeric
Was the AED data useful to clinical decision making? (4-point scale ranging from not useful to very useful)	Likert scale
Did this information do any of the following?	Multiple select
Provide insight into the etiology of the cardiac arrest.	Categorical
Provide insight into the quality of compressions or resuscitation efforts.	
Reduce unnecessary testing.	
Reduce length of hospital stay.	
Provide supporting evidence for a final diagnosis.	
Nothing, this information did not change the patient's course in hospital.	Free text
Can you tell us about any notable cases in which AED data changed patient outcome or management? Please leave out patient identifiers.	

AED, automated external defibrillator; CCU, critical care unit; CICU, coronary intensive care unit; OHCA, out-of-hospital cardiac arrest; RJH, Royal Jubilee Hospital.