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Clinical paper

The Minnesota first-responder AED project: Aiming to increase survival in out-of-hospital cardiac arrest

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Abstract

There are 350,000 out-of-hospital cardiac arrest (OHCA) cases annually in the United States of America. Using automated external defibrillators (AEDs) has increased survival in cardiac arrests (CA) with an initial shockable rhythm. Thus, guidelines recommend complete geographical coverage with AEDs. To fill in the gaps in Minnesota, the Center for Resuscitation Medicine at the University of Minnesota raised an $18.8 million grant from the Helmsley Charitable Trust to supply law enforcement first responders with AEDs and, thus, increase survival rates after OHCA by reducing the time to first shock. This report elaborates on the decision-making, fundraising, and logistic strategy required to reach statewide AED coverage.

Methods: The baseline need for AEDs was analyzed using a questionnaire sent out to state law enforcement agencies, state patrols, city and county agencies, and tribal agencies in 2021. Furthermore, OHCA cases of 2021 were reviewed. The combination of this information led to an action plan to equip and train all agencies throughout the state's eight regions with AEDs.

Results: The electronic survey was initially sent out to 358 agencies. The initial response rate was 77% ($n = 276$). This resulted in a total need of 8300 AEDs to be deployed over three years (2022–2025). As of 2023, over 4769 AEDs have been distributed, covering 237 sites.

Conclusion: By equipping first responders with AED systems, the Center for Resuscitation Medicine aims to shorten the gap in statewide AED coverage, thus increasing the chances of survival after OHCA.

Keywords: OHCA, AED, EMS, First responder

Introduction

There are over 350,000 out-of-hospital cardiac arrests (OHCA) cases yearly in the United States of America.[1] Nevertheless, survival rates after OHCA remain depressingly low, not even reaching 10% globally.[2]

Cardiac arrest (CA) requires prompt and effective intervention. As such, chest compressions are the gold standard of resuscitation, providing 20–25% of normal cardiac output.[3] Besides, few effective treatment options can terminate CA except for delivering early electric shocks during ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT). Although the overall rate of shockable rhythms in OHCA has gone down,[4,5] the prevalence can be as high as 60%.[6,7] This relatively high number underlines the necessity of rapidly-available automated external defibrillators (AED) in public places or with first responders, thus shortening defibrillation time. The optimal window for utilizing an AED is within 3–5 min of the collapse.[8–10] In settings where AEDs are rapidly available, survival after OHCA has been reported to be as high as 50–70%.[11–14]

The average response time of Minnesota Emergency Medical Services (EMS) systems is 8–10 min, which may not be sufficient for cardiac arrest victims.[9,15] First responders, for example, firefighters or law enforcement agencies, are thought to be able to provide much faster response times, especially in rural areas. Still, local audit data has shown that first responders lack access to AEDs and the requisite training, particularly in rural areas.[16] To deal with this considerable potential, the Minnesota first responder AED project was awarded an $18.8 million grant from the Leona M. and Harry B. Helmsley Charitable Trust to give more than 8300 AED to first responders over Minnesota to increase survival rates after OHCA

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(https://helmsleytrust.org/news-and-insights/18-million-grant-to-provide-aeds-across-minnesota/).

In this report, we detail the planning and execution of equipping the state of Minnesota with AEDs. We aim to guide similar AED implementation efforts in other large geographic regions.

Methods

The Center for Resuscitation Medicine is a collaborative initiative that aims to improve the outcomes of CA patients. It was founded in 2011 at the University of Minnesota. The Center for Resuscitation Medicine conducts research, education, and community engagement in resuscitation science. One of its achievements is developing and implementing veno-arterial extracorporeal membrane oxygenation (ECMO) facilitated cardiopulmonary resuscitation programs for patients with OHCA. The program has shown promising results in several case studies published by the University of Minnesota.[17–24]

Geographical considerations

The state of Minnesota is the 12th largest in the USA, with 5.7 million residents living in eight different regions. Almost 60% of residents live in the Minneapolis-Saint Paul metropolitan area, accounting for about 3.7 million people. The largest city is Minneapolis, with over 420,000 inhabitants. As such, the equal distribution of AEDs throughout Minnesota is challenging because of the different EMS systems and the size of the state (Fig. 1). Rural communities have substantial response delays because smaller towns rely on their police department or County Sheriff for 911 response (emergency telephone number for the USA) Fig. 2.

Initial assessment of AED usage and cardiac arrests in Minnesota

To analyze the need for AEDs, the Center for Resuscitation Medicine conducted an electronic survey within the first two quarters of 2021 (Supplement 1). The survey was sent to first responders from police agencies throughout the state of Minnesota. This questionnaire included questions about how many AEDs were available at the time of the survey and how many vehicles were utilized within each law enforcement agency. The survey was distributed to over 400 contacts of 358 agencies. The email contacts represented state patrol, city/county agencies, tribal agencies, campus police, emergency management officers, and the Department of Natural Resource/park patrols.

First responders were defined as police officers, firefighters, emergency medical technicians, federal law enforcement officers, and agents and 911 dispatchers.

The availability of AED devices throughout the state of Minnesota and their utilization was assessed in 2021 with the help of the Cardiac Arrest Registry to Enhance Survival (CARES).[25] A general assessment of EMS response times was done by the Cardiovascular Disease Unit of the Minnesota Institute of Health and used to determine where a more significant number of AEDs could be placed to reduce the response time of first responders to OHCA.

The equipment

The Center for Resuscitation Medicine decided to provide the Lifepack CR2 AED (Stryker, Kalamazoo, Michigan, USA). This device uses cprINSIGHT technology to analyze the heart rhythm during chest compressions and determine if a shock is needed. CR2 AEDs have WiFi capability and an 8-year full-service package that covers pad replacement, download support, case review, and customer service. The WiFi capability eases the monitoring of devices and uploading cases for review and for the free replacement of pads. By allowing for chest compressions during an electrocardiogram (ECG) rhythm analysis, this device was expected to reduce pauses between CPR and defibrillation, thereby limiting no-flow time. Additionally, the interconnection between AED devices will enable the Center for Resuscitation Medicine to analyze CPR quality further, as the devices can report CPR ratio times, compression ratio, and compression rate.[26]

Agencies could donate their older yet usable devices within their community or donate them to the Center for Resuscitation Medicine. The Center for Resuscitation Medicine has set up a recycling program with additional funding through the Lillihei Family Foundation, where these AEDs can be redistributed. Redistributed AEDs may be used in community settings or cities, and community awareness can be found in PulsePoint (a phone application for AED tracking and crowd-sourcing). For devices with expired FDA approval, Stryker offered to assist with the disposal of older units.

Potential outcomes

Based on the evaluation of the CARES registry data and the survey results, we aimed to improve the outcomes of OHCA patients in Minnesota by implementing a comprehensive program that involves placing AEDs in all law enforcement vehicles, ensuring connectivity in 75% of the deployed AEDs, developing a response process for AED users on events, and activating the mobile ECMO team earlier using the AED Event Viewer in the Minneapolis-St. Paul Twin Cities metropolitan area.

We hypothesized that these interventions would lead to earlier AED utilization by law enforcement officers and increased survival rates, especially in rural communities with limited access to advanced care.

Training and feedback

To ensure the proper use of the distributed equipment, the Center for Resuscitation Medicine set up a training program for first responders to educate them on using the CR2 AEDs. Through an online system, agencies can apply for training at the Center for Resuscitation Medicine and attend regional train trainer sessions to be taught the proper device's use. Training devices allow these 'trainers' to share information with their departments. Additionally, after a reported AED use, first responders are asked to fill in a questionnaire about the case and the implementation of the AED, which the Center for Resuscitation Medicine will analyze to offer further training, if needed, thus ensuring the highest resuscitation standards. To ensure the units distributed are connected, the Center for Resuscitation Medicine team has assigned a site support staff with 0.50 full-time equivalent to work with the agencies. Additional site staff will be crucial in data and quality review and connectivity for the AED Event viewer. This will involve ongoing management to identify the radius for possible ECMO activation and coordination with dispatch.

Connection to the extracorporeal cardiopulmonary Resuscitation (ECPR) program

The ECPR program of the University of Minnesota is one of the largest in the US and among the largest worldwide, with approximately

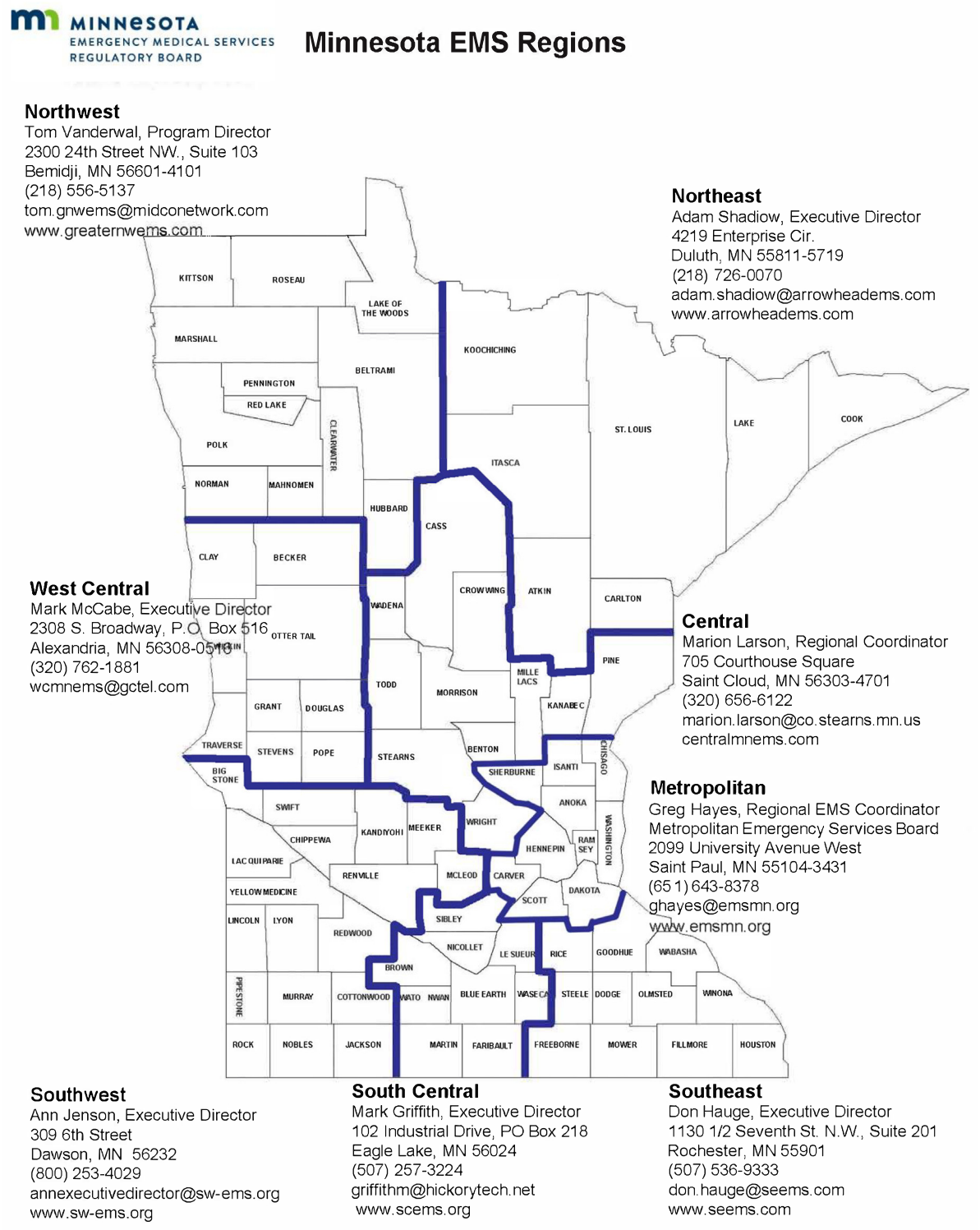


Fig. 1 – EMS regions in the state of Minnesota.

200 cases per year. The patient selection criteria and care strategies employed by clinicians in this ECPR program have been published previously.[18,21] Briefly, patients with CA and ongoing CPR meetings are eligible for EMS transport the following criteria to the closest participating ECMO Initiation Hospital cannulation site:

1) adults (aged 18–75), 2) initial shockable rhythm, OHCA, 3) no ROSC (return of spontaneous recirculation) following three shocks, 4) automated cardiopulmonary resuscitation with mechanical chest-compression device, and 5) estimated transfer time of <30 min.

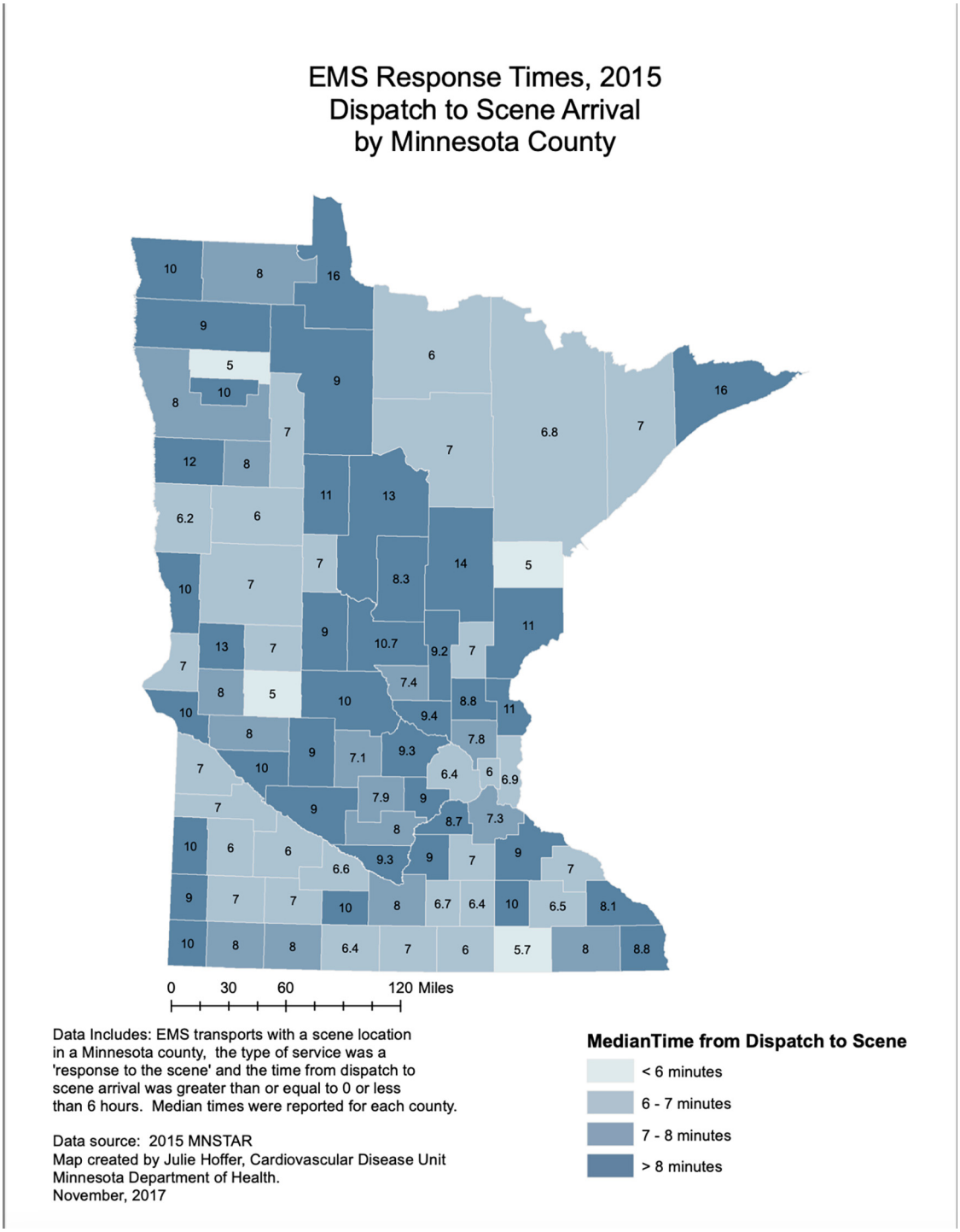


Fig. 2 – EMS-response times in 2015.

On eligible patient identification through the EMS team, the ECMO team will be notified through a central dispatcher, and the cannulation site will be determined. The mobile ECMO cannulation team also will be dispatched to the ECMO initiation hospital.

A potential overlap between the AED program could be an earlier activation of the mobile ECMO team based on Event Viewer, and an automated data notice from the AED, thus shortening low-flow times until the commencement of ECMO.

Results

CARES registry Analysis, Minnesota

There were 3243 CA cases during the year 2021 in the CARES Registry (a total of 99.9%, due to lost reporting and unknown cases).

Amongst these, 78% (n = 2529) occurred at home, and 21% (n = 681) presented with an initial shockable rhythm (Table 1).

Table 1 – Arrest- characteristics in Minnesota reported by CARES in 2021.

Cardiac Arrest Cases in 2021	N = 3243 (100%)
Females	1102 (34%)
Occurred at home	2529 (78%)
Bystander CPR	1200 (37%)
Initial shockable rhythm	681 (21%)
Public AED use	331 (10%)
Survival with CPC 1–2	292 (9%)

CPC = cerebral performance category.

Throughout registered CA in Minnesota, CPR is initiated by EMS in about 20% of cases, bystanders in about 38%, and first responders in nearly 42% of cases.[27]

This suggested that improving access to AEDs might allow for earlier defibrillation in an additional 681 patients within Minnesota.

Distribution of AEDs

Two hundred seventy-six completed surveys were collected. The response rate was 77% (Supplement 2).

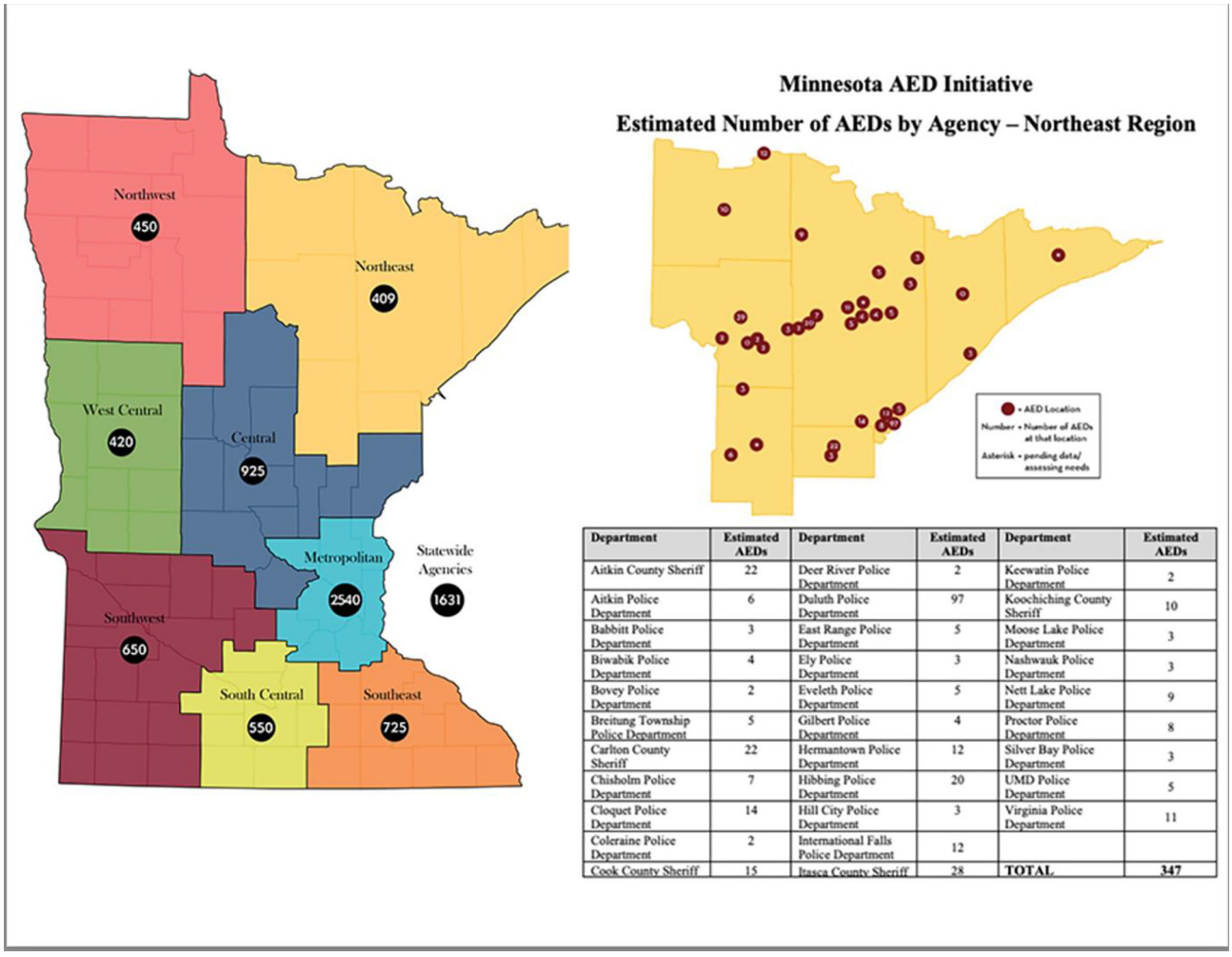
The survey estimated the need for additional AEDs, updated contact information, and agency changes.

Implementation

The distribution plan is depicted in Fig. 3 in relation to the different regions. Based on the gathered information, the distribution plan was made as follows:

Year 1: NorthEast, NorthWest, Metro, West Central, and Central Regions; Minnesota DNR: Minnesota State Patrol.
Year 2: SouthWest, SouthEast, and SouthCentral Regions.
Year 3: Remaining statewide agencies.

Until the middle of 2023, 4769 Stryker CR2 AEDs with WiFi across 237 sites have been distributed. 77 of the 237 or 32% of the sites are entirely active, meaning every device at each site is ready. For context, this number is low as any inactive device (for usage or any other reason) at a site will render the entire site unready. 3881 of the 4769, or 81% of the devices, have been connected to WiFi or manually updated. 708 devices have not been connected yet. 2705 are in ready status, and 1147 have been connected but are outdated.



Department	Estimated AEDs	Department	Estimated AEDs	Department	Estimated AEDs
Aitkin County Sheriff	22	Deer River Police Department	2	Keewatin Police Department	2
Aitkin Police Department	6	Duluth Police Department	97	Koochiching County Sheriff	10
Babbitt Police Department	3	East Range Police Department	5	Moose Lake Police Department	3
Biwabik Police Department	4	Ely Police Department	3	Nashwauk Police Department	3
Bovey Police Department	2	Eveleth Police Department	5	Nett Lake Police Department	9
Breitung Township Police Department	5	Gilbert Police Department	4	Proctor Police Department	8
Carlton County Sheriff	22	Hermantown Police Department	12	Silver Bay Police Department	3
Chisholm Police Department	7	Hibbing Police Department	20	UMD Police Department	5
Cloquet Police Department	14	Hill City Police Department	3	Virginia Police Department	11
Coleraine Police Department	2	International Falls Police Department	12		
Cook County Sheriff	15	Itasca County Sheriff	28	TOTAL	347

Fig. 3 – AED distribution plan. * including a detailed Plan for the Northeast Region, sercing as an example for the ongoing distribution.

Furthermore, over 700 AEDs have been donated for redistribution thus far. As the distribution of AEDs is an ongoing and fluid process, some agencies have received more or fewer AEDs than calculated upon the initial assessment. Agencies initially stating that they would not be participating could revoke their decision later on and still participate in the program.

The Northeast region has 36 agencies, of which two declined, adding up to a total of **467** devices; Northwest had 30 agencies, with only two declining, with a total of **410** devices; Central had 60 agencies, with three declining with a total of **839** devices, these agencies may be included in future pieces of training as they had some obstacles that could not be resolved in time for training; Metropolitan had 93 agencies with eight declining or unable to attend with a total of **1621** devices; West Central had 33 agencies with only one that we were unable to reach and no other declining with a total of **306** devices; and Southwest had 59 agencies with only two declining with a total of **569** devices.

Additional devices were distributed to statewide agencies, including the MN State Patrol, the Department of Natural Resources, and the MN Public Safety Office.

The completion of South Central and Southeast is planned for May 2023.

Discussion

The Minnesota AED project aims to equip law enforcement and other first responders in Minnesota with 8300 AEDs in 3 years. This will address gaps in the statewide AED coverage. It will provide accessible tools for training and feedback on cardiac arrest calls. The Center for Resuscitation Medicine will ensure that agencies can use the AEDs, troubleshoot any concerns, and help them celebrate lives saved in their communities. Distributing WiFI-capable AEDs that can provide notification upon use will connect the AED with the ECPR team to expedite the activation of ECPR protocols.

On the decision to equip first responders with AEDs in community places

AEDs can deliver electric shocks to restore normal heart rhythm in patients who suffer from CA. Early defibrillation, before the EMS arrival, is a favorable predictor for survival.[28,29] As we have seen in our evaluation, the time between EMS emergency calls and appearance on the scene is over 8 min in most areas in Minnesota, and most OHCA happens in patients' homes (Table 1). Although it has been shown that placing AED in public places can have a tremendous impact on survival rates for OHCA, less than 5% of OHCA patients are shocked before EMS arrival.[6,29] It has also been shown that public AEDs are infrequently used in private settings compared to public.[30] Thus VF survival rates are lower for patients who experience OHCA at home than in a public place (34.5% vs. 50.9% in 2019).[27] This can mainly be explained by the fact that for private locations, the witness performing CPR is often alone and unable to leave the scene or send someone to get an AED stored in a public site.

Defibrillation should be provided within the first minutes of VF to improve survival rates. Each minute delay decreases the chances of successful defibrillation.[9,10] Enabling fast access to an AED as fast as possible for the patient becomes essential, even more so in rural areas where EMS arrival delays are longer.[31,32]

A meta-analysis of 10 published studies showed that implementing AEDs in police officers' cars as part of a Police AED program significantly decreased mean time to defibrillation significantly, from 9.5 ± 2.4 min to 6.1 ± 0.6 min. This drop in time to shock also led to a significant increase in survival (28.6% when shocked by EMS vs. 39.4% when shocked by the police, $p < 0.001$.[33] A recent cohort study in Austria showed that the time until the first shock can be divided by about half when police officers are equipped with AEDs, and thus, a significantly higher survival to discharge was achieved.[34]

Minnesota has higher rates of AEDs in law enforcement and first responders but still has significant gaps and does not have AEDs in all 911 responding vehicles. By placing AEDs in law-enforcement vehicles, we can increase the availability and accessibility of these devices for responders who arrive first at the scene of an OHCA. This will enable them to provide early defibrillation, a critical factor in improving survival.

Implementing first responder OHCA-Care systems with EMS-systems

By implementing feedback loops and organizing training, most first responders should feel confident in performing CPR and AED correctly. By using the feedback and report system of the CR2 AEDs, the Center for Resuscitation Medicine will evaluate the quality of CPR and be able to offer refresher courses and additional and/or specific training programs to first-responder systems that were shown to have unfavorable CPR performance, thus delivering the highest quality of CPR throughout the state. Such feedback systems need open communication among all stakeholders. Early results from cases to date have shown that law enforcement officers are performing CPR at a high level consistently until EMS arrives. Of the initial cases, approximately 30% of AED uses have resulted in patients surviving emergency room admission.

Challenges

Moving forward, a key obstacle for the study system and similar systems is to find ways to enhance the identification and dispatching of OHCA so that the police can intervene more rapidly without significantly increasing their workload. Alternatively, the police might be open to broadening their response to these situations, accepting a great proportion of arrests overall, with the understanding that only a smaller proportion of these responses will involve cases of actual cardiac arrests.

An additional challenge is the WiFi connectivity. Law enforcement and first responders often lack WiFi while working remotely. The devices require a monthly WiFi check-in to ensure readiness, and they upload the case immediately after use. This provides the case review and initiates the pad replacement. The event viewer program is only effective when in a WiFi setting, which is optimal for the early activation of the ECMO team. Even in vehicles where that carry a WiFi hotspot, this does not usually reach the patient's location where the AED is in use.

Limitations

This report renders a variety of limitations. First, the initial planning to distribute AEDs was made based on CA in Minnesota, derived from CARES. As such, CARES does not account for all CA in the state. There are cases that were not added to the registry. Furthermore, all data added to the registry rely on accurate reporting of professionals involved in the CA, and thus inaccurate recordings may have biased the initial planning. Second, the jurisdiction of emergency

services throughout the state, as well as their provision of AEDs, has changed over the time of planning and also distribution. Thus, overall distribution and equipping is a fluid process that requires continual adjustments on the part of the providers and recipients. Accordingly, in some areas, more AEDs were distributed than planned, and the initial numbers are challenging to maintain over a multi-year process. Third, this manuscript does not constitute a paper in the strict sense. Rather, it is a report and is intended to serve as a guide for planning and successfully applying for major projects, such as equipping a state with AEDs. We report data on distribution and equipping in an ongoing process. Accordingly, we chose not to report hard outcomes and target parameters, but only to describe the planning of the distribution of AEDs.

Conclusion

By providing over 8000 AEDs to first responders throughout Minnesota, the Center for Resuscitation Medicine of the University of Minnesota aims to fill the gaps in AED coverage and thus increase survival rates after OHCA. As such, the AED program might shorten the interval between the occurrence of OHCA and first defibrillation.

CRediT authorship contribution statement

Christopher Gaisendrees: Conceptualization, Formal analysis, Writing – original draft. **Deborah Jaeger:** Methodology, Formal analysis, Writing – original draft. **Rajat Kalra:** Conceptualization, Data curation, Writing – review & editing. **Marinos Kosmopoulos:** Writing – review & editing. **Kimberly Harkins:** Writing – review & editing. **Alexandra Marquez:** Conceptualization, Data curation, Writing – review & editing. **Lucinda Hodgson:** Validation, Writing – review & editing. **Loren Kollmar:** Validation, Writing – review & editing. **Jason Bartos:** Validation, Writing – review & editing. **Demetris Yannopoulos:** Validation, Writing – review & editing.

Declaration of Competing Interest

Prof. Yannopoulus reports a relationship with Leona M and Harry B Helmsley Charitable Trust that includes: funding grants.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2023.100437.

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