

Article

Cardiopulmonary Resuscitation Training and Automatic External Defibrillators Deployment: Strengthening Community Response to Cardiac Arrest

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Abstract: The most effective strategy to save the life of a victim of out-of-hospital cardiac arrest (OHCA) is to provide aid as early as possible. To achieve this objective, widespread dissemination of knowledge on basic life support and defibrillation (BLS/D) in the general population is necessary. In recent years, evidence has been emerging supporting the effectiveness of public-access defibrillation (PAD) programs; the diffusion of automatic external defibrillators (AEDs) and the knowledge of their correct use among lay rescuers are associated with a higher survival rate and better neurological outcomes among OHCA victims. This study aims to implement and monitor a BLS/D training program involving an entire city in Italy. Since 2016, a PAD program has been implemented in Busca (CN), a small town in the northwest of Italy. The project was divided into three phases: (1) the diffusion of AEDs in the most-frequented places in the city; (2) BLS/D training aimed at reaching the most significant possible number of citizens; (3) the training of all schoolchildren in the basics of first aid. The retention of the concepts learned was assessed via a multiple-choice questionnaire proposed months after the training events. From 2016 to 2023, 42 BLS/D courses were held, which trained 1302 adults (12.8% of citizens) with a female/male ratio of 0.9 and a median age of 46 (range: 32–59 years). The participants in the courses were volunteers from associations (59%), athletes (16%), ordinary citizens (13%), school staff (10%), and municipal employees (2%). At the start of the project in 2016, the first 11 AEDs were positioned. To date, the municipal area can count on 25 always-available defibrillators to reach each area within 4 minutes. Furthermore, 1500 school pupils were trained. The retention of the learned notions was excellent. After training, 92% of adult participants and 90% of the schoolchildren reported being willing to provide help in the event of cardiac arrest. The project combined the widespread diffusion of AEDs with a significant number of citizens able to use them, effectively providing cardiopulmonary resuscitation. This project ensured that an entire community shared the goal of saving the lives of people affected by OHCA.

Keywords: out-of-hospital cardiac arrest; basic life support and defibrillation; public access defibrillation



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1. Introduction

Out-of-hospital cardiac arrest (OHCA) has an incidence of 89/100,000 inhabitants per year in Europe, where it represents the third cause of death [1]. The survival rate to discharge is still relatively low (just over 10%), although the factors related to better

prognosis (both for survival and good neurological outcome) are well known; among these, the implementation of cardiopulmonary resuscitation (CPR) by bystanders and the early use of the automatic external defibrillator (AED) stand out [2–5]. However, the rate of bystander initiation of CPR remains low, presumably less than 50% of OHCA cases [6], and even more discouraging is the rate of AED use, which appears to be less than 10% [7].

The role of bystanders in providing first aid for OHCA through early CPR is vital [8]. Each community must ensure that all possible initiatives are implemented to increase the survival of cardiac arrest victims. This can happen at international, national, and local levels. An objective cited by the most recent guidelines of the European Resuscitation Council (ERC) is the development of new and innovative systems and policies that will save more lives.

Among the suggested community initiatives to promote CPR implementation are the following:

- Instructor-led training sessions: Widespread training of laypersons in high-performance CPR and AED resulted in more patients receiving bystander CPR and defibrillation, which is associated with increased survival rates [9].
- Public access defibrillation (PAD) projects: The International Liaison Committee on Resuscitation Consensus on Science and Treatment Recommendations (ILCOR) made a strong recommendation in support of the implementation of public-access defibrillation programs [10]; the implementation of PAD programs has already proven effective not only in the earlier administration of shocks by laypersons but also in increasing the survival rate with minimal neurological impairment [11].
- Student training: Student training has the most significant and lasting impact on improving the rate of bystander CPR [12]. It has been hypothesized that implementing mandatory resuscitation training in elementary schools and when acquiring a driver's license may increase OHCA survival [3]. Teaching the concepts of BLSD (basic life support and defibrillation) and the chain of survival to younger people, also using new technologies, is a vital strategy to educate future generations to respond to cardiac arrest, thus increasing the number of trained people and enhancing survival after OHCA [13].

Several implementation measures have been taken in Italy to improve public response to OHCA. Training programs have been implemented to educate the general population on basic life support techniques and the proper use of AEDs. These programs aim to increase the number of individuals capable of providing immediate assistance in cases of cardiac arrest. Mandatory school training has been emphasized to ensure that young people are equipped with life-saving skills. Programs like the ERC “Kids Save Lives” initiative focus on teaching schoolchildren basic life support skills and AED operation.

Distribution of AEDs:

Public-Access Defibrillation (PAD) Programs: A key strategy in Italy has been the widespread dissemination of AEDs in public spaces and high-traffic areas. Placing AEDs in easily accessible locations increases the chances of early defibrillation by bystanders, which is crucial for improving survival rates in OHCA cases. Public awareness campaigns have been conducted to promote the importance of early intervention in cardiac arrest emergencies. Mass training sessions have been organized to raise awareness about AEDs, address psychological barriers to intervention, and educate the community on the steps to take in an emergency. Efforts have been made to inform the public about the presence and use of AEDs and dispel myths and fears surrounding their use. These campaigns aim to increase public confidence in responding to cardiac arrest situations. Laws such as Law 116 of 2021 in Italy have encouraged the spread of AEDs, mandated CPR training in schools, and promoted information campaigns on cardiac arrest response [14]. These policy changes aim to create a supportive environment for community-based OHCA response programs. However, there is a gap in the knowledge about the implementation of cardiac arrest response programs in Italy.

The aim of this study is to report on the implementation of measures of a community-based cardiac arrest response program in Busca, Italy, focusing on training initiatives, AED deployment strategies, and the involvement of schoolchildren in acquiring life-saving skills.

2. Materials and Methods

This study is a retrospective analysis of a community-based cardiac arrest response program implemented in Busca, province of Cuneo, in northwest Italy. The local ethics commission (Municipality of Busca Legal/Ethics office Comune di Busca) reviewed and approved the project itself (DGC 344, 11 June 2016) and the study (DGC 23, 10 January 2024). The program was launched in 2016 and is still continuously expanding. Here, we describe the initiatives undertaken over the years to make the city safer and more resilient towards health emergencies. The effectiveness of the AED network, the adult population's involvement rate, the willingness to intervene before and after attending the courses, and the effectiveness of the training aimed at school pupils were evaluated. We have created a detailed curriculum outlining the key concepts, skills, and procedures to be taught during the training sessions for both adults and children. After that, we ensured that instructors were trained and certified to deliver the training program effectively and consistently. We have regularly monitored and evaluated training sessions to ensure adherence to the curriculum and maintain quality standards. We have gathered feedback from participants to identify areas for improvement and make necessary adjustments to enhance the training program. To ensure a consistent quality of training for the participants, we provided instructors with standardized training materials to ensure consistency in content delivery. We have conducted regular training sessions for instructors to update their knowledge and skills and ensure they deliver training according to established guidelines. We have implemented periodic quality control checks during training sessions to assess the effectiveness of instruction and provide feedback for improvement. Questionnaires (Supplementary Table S1) were administered before the courses and a few months after the training events were undertaken, and the variables relating to the course participants were described; participants were informed before attending the courses and gave consent for the questionnaire results to be used in the study. We also described the emergency events that occurred in the city during the years of the study.

Statistical Analysis

A comprehensive statistical analysis of key metrics assessed the program's effectiveness. Descriptive statistics were utilized to characterize the population reached by the BLSD training program, including demographic profiles and participation rates. Additionally, participants' retention of learned concepts was evaluated using pre- and post-training questionnaires. The analysis revealed a high willingness among adults and schoolchildren post-training to intervene in OHCA scenarios. Real-life event data were also analyzed to assess the program's impact on OHCA outcomes, including successful AED deployments and bystander interventions. To collect and access data on OHCA cases and emergency events for the study, we have worked closely with local emergency medical services (EMS) providers to access data on OHCA cases and emergency events in the community. We have also ensured compliance with data protection and privacy regulations when accessing and analyzing sensitive medical information. Lastly, we have analyzed the collected data to evaluate the training program's impact on OHCA outcomes and identify areas for improvement in community response to cardiac emergencies. The local ethics commission reviewed and approved the project itself and the study. Statistical analyses were performed using the software JASP (2022, Version 0.16.3, JASP Team, BibTeX, Amsterdam, The Netherlands).

3. Results

The programs aimed to increase the survival rates of individuals experiencing out-of-hospital cardiac arrest. Data on survival rates post-implementation of the programs were not explicitly calculated. The programs focused on training community members,

including schoolchildren and adults, in basic life support and defibrillation. Post-training assessments indicated high willingness among participants to intervene in OHCA scenarios; nevertheless, specific data on actual bystander intervention rates in OHCA incidents were not calculated. The programs involved positioning AEDs in the municipal area, with 25 defibrillators available within 4 min of any location. The AEDs were combined with a significant number of trained citizens, enhancing the community's ability to provide effective cardiopulmonary resuscitation. The number of AED deployments and their impact on OHCA outcomes were not explicitly detailed.

The initiatives implemented for this project are referred to in three main areas (Figure 1).

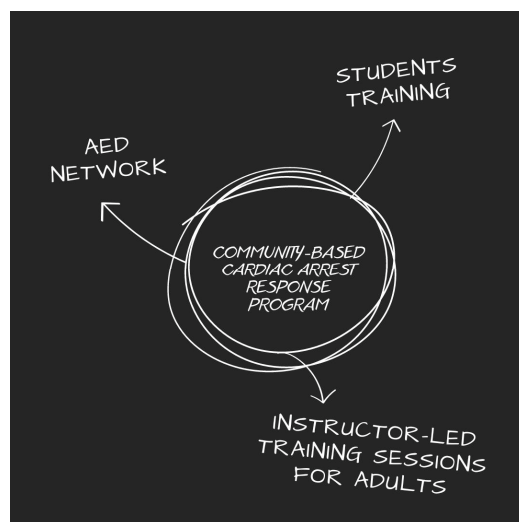


Figure 1. The areas of intervention for the community-based cardiac arrest response program.

3.1. The AEDs Network

The municipality of Busca has an extension of 65.85 km², and the territory is predominantly mountainous and hilly; the city consists of a historic center and some hamlets. Starting in the autumn of 2016, AEDs were positioned first in the streets of the historic center and then in the main hamlets (Figure 2). The AEDs are placed in the most crowded areas (main streets and squares) and areas of significant interest: schools, churches, bus terminals, and sports facilities. All AEDs are placed outside buildings, always available to the entire population 24 h a day, 365 days a year; all schools and sports facilities are equipped with an AED. The Municipality have conducted site visits to evaluate the physical placement of AEDs in various locations and have assessed factors such as proximity to high-traffic areas, ease of access in emergencies, and visibility of AED signage. AEDs also have pads for pediatric use in schools and sports facilities. The Municipality had engaged with key stakeholders, such as local community members, school staff, and emergency responders, to gather their perspectives on the effectiveness of the AED network and its impact on community safety. There are twenty-five AEDs, of which twenty-three are fixed installations and two are mobile AEDs on police and fire brigade vehicles. The correct functioning of the AEDs is checked every week, and each AED is subjected to a complete test every year, with the replacement of expired components. Fifteen AEDs are located in the historic center, and eight are in the most-populated hamlets. The positioning of the AEDs responded to the requirement that the AED itself could reach every point of the center and of the involved hamlets within 4 min. To make the position of the AEDs known to the majority of citizens, the AEDs are marked with special signs, panels reporting their position have been placed in various points of the city, and flyers have been created showing the map of the town with the location of the AEDs. Furthermore, the presence of the AEDs is also reported on the city's website and smartphone apps.

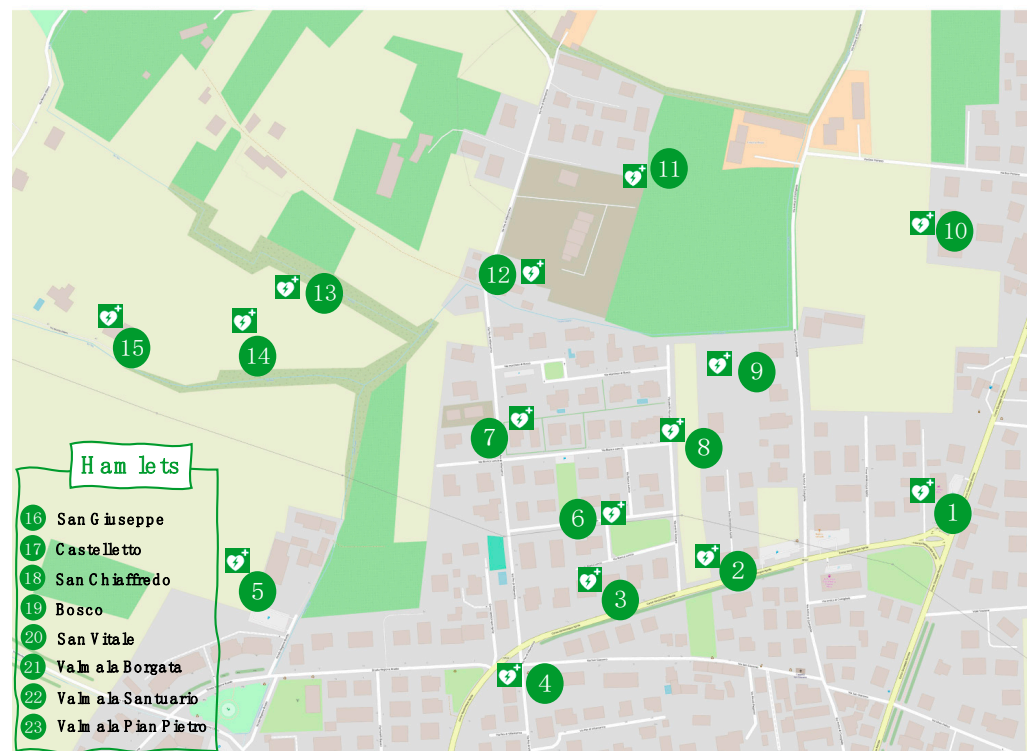


Figure 2. The AEDs network.

3.2. BLS Training for Adult Citizens

To create a relevant number of citizens ready to intervene in case of emergency, BLS training sessions were periodically organized, and all 10,147 inhabitants were invited to participate (Table 1). From 2016 to 2023, considering the suspension due to the COVID-19 pandemic, 42 BLS sessions were held, which trained 1302 adults (12.8% of citizens) with a female/male ratio of 0.9 and a median age 46 (range: 32–59 years). Lessons last 4 h. In the first part, the participants are instructed as to the phases of the chain of survival (recognition of cardiac arrest, calling for help, early cardiopulmonary resuscitation, and early defibrillation) and the manoeuvres to unblock the airways in the event of choking; manoeuvres are taught for adults, children, and infants. In the second part of the lesson, the participants can try the manoeuvres on manikins with the use of training-only AED in small groups with an instructor; the participant ratio is 1:6. The participants were volunteers from the city's associations (59%), athletes and coaches (16%), ordinary citizens and traders (13%), school staff (10%), and municipal employees (2%). In this way, we obtained an almost constant presence of people trained in BLS in schools, sports facilities, and on the city streets, and we guaranteed first responders' presence at social gatherings in the city; in addition, the preparedness of civil protection operators has increased, as all of them participated in the courses. According to a before/after survey, 15% of participants would have felt ready to help a victim of OHCA before attending the courses; after the training, 92% of participants reported being willing to act to provide help.

Table 1. Characteristics of 1302 BLS course participants.

Median age (range), years	46 (32–59)
Female/male ratio	0.9
Volunteers	59%
Athletes and coaches	16%
Ordinary citizens and traders	13%
School staff	10%
Municipal employees	2%
Willingness to act before the course	15%
Willingness to act after the course	92%

3.3. Training for Schoolchildren

Since 2021, our project has systematically involved children attending the city's schools in a broader provincial-based training context promoted by the local EMS. Schoolchildren from first grade (approximately six years old) to eighth grade (around 13 years old) were involved in the training program. The training curriculum for schoolchildren included teaching cardiac arrest recognition, emergency call procedures, airway unblocking manoeuvres, chest compressions, and AED operations. The program aimed to equip children with essential life-saving skills and knowledge to respond effectively to cardiac arrest emergencies. In addition, all 6-year-olds are taught how to contact the emergency number 112; 10-year-olds are taught airway unblocking manoeuvres in case of choking; at 11 years old, children learn to perform chest compressions for cardiac arrest victims; at 13 years, schoolchildren are finally trained in the use of AED. A total of 1572 children have been trained so far. Learning was verified with a test administered four months after the courses. Of the 6-year-old children, 100% correctly remembered the number to call in case of emergency, and 86% remembered all the things to communicate during the emergency call; 93% of 10-year-old students could recognize a total airway obstruction, 91% could recognize a partial airway obstruction, and 95% knew how to intervene in case of total airway obstruction. The older children, trained on chest compressions and AED use, correctly recognized cardiac arrest in 75% of cases, 86% remembered the exact sequence of the chain of survival, and 90% knew how to perform high-quality CPR. All of the children agreed with teaching first aid at school, and 94% stated they were ready to act in cardiac arrest after following the courses. Post-training assessments indicated a high willingness among schoolchildren to intervene in OHCA scenarios. The learning was verified with a test administered four months after the courses, suggesting a structured approach to assessing knowledge retention.

3.4. Real-Life Events

Over the years, there have been 3 cases of witnessed cardiac arrest in which a public AED was used; in one case, a return of spontaneous circulation (ROSC) was obtained. In a fourth case of cardiac arrest, ROSC was achieved upon emergency services arrival without the use of an AED, i.e., with early CPR alone. A 10-year-old girl managed to contact emergency services for her mother, who had suffered a stroke; a 12-year-old boy successfully unblocked his brother's obstructed airway.

4. Discussion

This study demonstrated the feasibility of a community-based cardiac arrest response project. This project is not just a public access defibrillation program; alongside the positioning of AEDs in the city area, we also wanted to create a community of citizens capable of responding to emergencies. We achieved encouraging results in several contexts: the number of available AEDs, the involvement of adults and schoolchildren in the courses,

the rate of willingness to intervene in the event of cardiac arrest, and the retention of the learned information.

The European Resuscitation Council Guidelines for Resuscitation 2015 stated that the community's response to improving survival from OHCA establishes an effective interaction between the medical emergency services and the bystanders who provide early CPR and use the AEDs made available by the public authorities [15]. All citizens must know the phases of the survival chain, becoming aware that the protagonists of the first links (early recognition and call for help, early bystander CPR, and early defibrillation) are the ordinary people; it is necessary to train the population so that everyone can be an efficient actor within the chain of survival [16].

In recent years, evidence of the effectiveness of PAD programs is increasing. Randomized trials have also been conducted with encouraging results [17]. A systematic review and meta-analysis concluded that bystander AED use was associated with improved survival and favourable neurological outcomes in OHCA patients [18]. A Japanese population-based cohort study showed that a significantly higher proportion of patients who received cardiopulmonary resuscitation combined with public-access defibrillation before the EMS response achieved a better neurological outcome 30 days after the OHCA than those who received cardiopulmonary resuscitation alone [19]; these results represent one of the most solid and evidence-based drives for the implementation of PAD programs in the community.

Different approaches to PAD program development are currently available. Traditional PAD projects with on-site and easily accessible AEDs are associated with a nearly double 30-day survival [20]. Another approach to OHCA is volunteer responder programs using on-site AEDs: a trial reported increased bystander CPR rates when adding volunteer responders to the standard EMS response [21]. Moreover, the dispatch of mobile AEDs by police officers, firefighters, taxis, and drones has been evaluated [22].

PAD programs saved many lives so far; however, much remains to be done to increase the rate of AED use by bystanders. A recent ILCOR statement promoted a multi-layered approach aimed at improving various steps on the pathway from cardiac arrest occurrence to early defibrillation and successful resuscitation [23]. In developing our project, we tried to respond to each of the inputs in the statement (Figure 3).

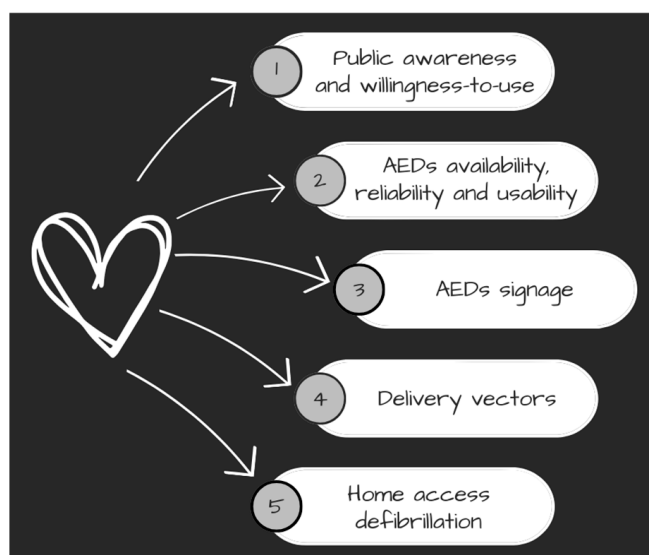


Figure 3. Cardiac arrest response program cornerstones.

- Improving public awareness and willingness to use: By mass-training the population, we raised citizens' awareness of AEDs function and location; in the training sessions, we addressed psychological problems (causing harm fear) and legal liability, which often constitute barriers to early defibrillation.

- Optimizing AED availability, reliability, and usability: In our city, citizens are now aware of the presence of AEDs, which are part of the city itself. The AEDs are always available 24 h a day (for example, the AEDs serving schools are positioned outside the buildings to be used during closing hours). Careful and constant maintenance reduces the possibility of malfunctions.
- AED registration: All AEDs are reported on the regional portal so that the dispatcher can instruct bystanders on the location of the AEDs.
- AED signage: All defibrillators are marked with the universal sign, and we have created flyers and maps reporting their position. For example, the location of AEDs is also shown on tourist maps.
- Strategic delivery vectors: Municipal police and fire brigade vehicles are equipped with defibrillators.
- Home access defibrillation: AEDs are also widespread in residential areas, and condominium training projects are about to be launched.

In addition to the availability of AEDs, training is the cornerstone of our project. The training aims to increase CPR rates, AED use, and timely EMS activation in OHCA. The guideline recommends “train as many citizens as possible”. Bystander CPR can double survival [4,24], and training members of the general population in CPR and using AED has resulted in higher bystander CPR and defibrillation rates, which was associated with improved survival [9]. Training in using AEDs ensures that rescuers are more familiar with their use when required in the case of OHCA [25].

Our training project is also aimed at young people. Nationally mandatory student training has the most significant and sustained impact on improving rates of bystander CPR [26]. For example, the ERC “Kids Save Lives” program is a global initiative to teach schoolchildren basic life-saving skills [27]. A simple check–call–compress algorithm is recommended for all schoolchildren [28]; younger children can also operate an AED [14,29]. ILCOR recently recommended creating new generations capable of responding effectively to OHCA, as young people are motivated to learn BLS and spread their knowledge in the community [28]. Our effort was to incorporate BLS and the chain of survival stages into a well-defined school curriculum.

The training program for children aimed to equip them with age-appropriate life-saving skills, mainly focusing on pediatric CPR. To evaluate its effectiveness, the curriculum was compared with established guidelines for pediatric CPR training, such as those set by the American Heart Association or similar organizations. The program’s content and outcomes were assessed to gauge its adherence to best practices. Furthermore, knowledge retention among children post-training was evaluated. For adult participants, bystander response rates before and after training were compared to measure the program’s impact on participants’ willingness to intervene in OHCA scenarios. Adult participants’ confidence and proficiency in using AEDs post-training were also evaluated. These outcomes were compared to established benchmarks in the field to indicate whether the program successfully enhanced participants’ ability to deploy AEDs in emergencies. Moreover, the impact of the training on AED deployment rates in the community was assessed to provide valuable insights into its real-world effectiveness. In terms of strengthening community response, a comparative analysis will determine how the study’s implementation measures stacked against existing cardiac arrest response programs in other communities.

The unique aspects of the study that contributed to a more robust and effective response were highlighted, providing valuable lessons for improving emergency response strategies. Furthermore, the multi-layered approach adopted in the study incorporates public awareness campaigns, AED deployment strategies, and training initiatives to enhance community readiness and response capabilities. Comparing this multi-faceted approach to single-focused interventions highlighted its advantages in preparing communities for cardiac emergencies. The sustainability and scalability of the implementation measures could be replicated in other communities to strengthen overall cardiac arrest response

systems. Identifying key factors contributing to sustainability and scalability ensured that the program's impact extended beyond the initial implementation phase.

Limitations

Despite its success, the program faced several limitations. First, the study's retrospective nature may have introduced biases or limitations in data collection, potentially impacting the accuracy and completeness of the findings. Additionally, while the program achieved significant participation rates among adults and schoolchildren, it may not yet have reached all segments of the population equally, potentially leading to disparities in OHCA response capabilities across different demographic groups. Furthermore, the study's focus on a single city limits the generalizability of its findings to other contexts with differing demographic, cultural, and infrastructural characteristics. Moreover, the evaluation primarily relied on self-reported willingness to intervene, which may only sometimes align with actual behaviour in emergencies. Finally, the sustainability and long-term impact of the program beyond the study period remain uncertain and warrant further investigation. Despite these limitations, the program represents a significant step towards improving community-based OHCA response and provides valuable insights for future initiatives in this field.

5. Conclusions

One of the most exciting aspects of BLS training is its ability to empower everyday individuals to become first responders. This empowerment promotes a culture of community resilience, in which individuals take responsibility for their ability to save lives and contribute to the well-being of others. BLS initiatives contribute to a safer, more compassionate society where everyone has the knowledge and confidence to act decisively in an emergency. We described the implementation of a project that created a stronger community through the widespread diffusion of AEDs and the extensive training of young people and adults. Willingness to act in case of cardiac arrest and retention of information learned were excellent for both adult participants and schoolchildren.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/ecm1030022/s1>: Supplementary Table S1: the surveys for adults and for schoolchildren participants.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics office Comune di Busca (DGC 344, 11 June 2016 and DGC 23, 10 January 2024).

Informed Consent Statement: Not applicable.

Data Availability Statement: The authors confirm that the data supporting this manuscript are available.

Conflicts of Interest: The authors declare no conflicts of interest.

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