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Governance and Maintenance of Public Automated External Defibrillators in Lebanon

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Abstract

Aims: The study aims were to identify how institutions that acquired automated external defibrillators (AEDs) manage cardiac arrests, and barriers to the use of these devices. **Methods**: A cross sectional survey of employees and managers of 75 institutions that had AEDs was conducted using interviews. The questionnaire addressed experiences with arrests, resuscitation practices and challenges, factors associated withandbarriers to the use of AEDs. **Results**: The institutions surveyed experienced on average 3.2 cardiac arrests/year. Most institutions did not document the arrests nor had guidelines to manage them. Most institutions trained their employees in resuscitation and use of AEDs but not regularly.Two thirds of the institutions got the AED either as donation or because it was recommended by a physician, and more than 50% kept the device under lock. The most frequent barriers to use of AEDs are their cost, believing that only health professionals can operate them and lack of knowledge about them. In the multivariable regression analysis, barriers to using AEDs were predicted by placing the device in a closed area. **Conclusion**: To reduce mortality and morbidity following cardiac arrests, a government sponsored public access defibrillation program and community training in resuscitation and AED use are recommended.

Keywords: out-of-hospital cardiac arrest; automated external defibrillator; survey; public access defibrillation; resuscitation

1. Introduction

Out of hospital cardiac arrests (OHCA) are among the most frequent causes of death and the leading cause of healthcare expenditures, with a global incidence among adults of 55 per 100,000 person-years (Berdowski et al., 2010). Around 70% to 90% of OHCA victims die before reaching the hospital (Graham et al., 2015; Neumar et al., 2015). Survivors of OHCA, if not resuscitated promptly, develop complications such as neurologic deterioration. The American Heart Association (AHA) launched a campaign to improve public awareness, mortality and morbidity outcomes of OHCA victims (Merchant et al., 2020) . The campaign includes a chain of survival with five components: 1) Immediate recognition of cardiac arrest and activation of the emergency medical services (EMS), 2) high quality cardiopulmonary resuscitation (CPR), 3) defibrillation, 4) additional advanced life support, and 5) post-cardiac arrest care and recovery (Merchant et al., 2020).

Sudden cardiac arrest is often caused by ventricular fibrillation, which can be successfully treated with defibrillation. CPR and use of an automated external defibrillator (AED) within minutes of OHCA can dramatically increase survival rates (Neumar et al., 2015; Valdes, 2015).Moreover, the AHA called for public access defibrillation (PAD) programs that make AEDs available in public places (Merchant et al., 2020).

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PAD programs help reduce the time to defibrillation, as AEDs can be operated by lay persons present at the scene. Studies have shown that early defibrillation is beneficial regardless of who performs it, can be applied safely when laypersons are trained in operating the AED, and promotes survival more than CPR alone (Bækgaard et al., 2017).PAD programs include the following: 1) Training in CPR and use of AEDs; 2) physician oversight for quality control; 3) integration of the PAD program with the EMS system; and 4) using and maintaining the AED (Nichol et al., 1997). PAD programs were found to be effective in achieving good neurological outcomes following OHCA from ventricular fibrillation (Perkins et al., 2015). In addition, deployment of AEDs in public places can be cost effective in saving lives if there was at least one cardiac arrest every five years, as shown in a simulation study (Cram et al., 2003). In Brazil, placing AEDs in a subway with community training on their use showed significant improved survival of OHCA victims and minimal neurological compromise (Gianotto-Oliveira, et al.,2015). Investigators recommended placing AEDs in areas where cardiac arrests are frequent (Centers for Disease Prevention and Control: Division of Heart Disease and Stroke Prevention [CDC], 2018), and ensuring their regular maintenance(Mao & Ong, 2016).In fact, AEDs are increasingly being deployed in public facilities such as malls, airports and schools, in order to ensure quick defibrillation(Weisfeldt et al., 2011).

In Lebanon, a country of 4.5 million population, the survival rate of OHCAs at hospital discharge was reported to be 5.5%, with good neurologic outcomes noted in only 45.4% of the survivors (El Sayed et al., 2014). The country does not have a national public EMS system, with emergency services run by organizations such as the Lebanese Red Cross (LRC). AEDs started becoming available in some ambulances in 2007; then in 2015, the LRC got 1,000 AEDs and other EMS organizations followed suit. In 2019 and following a one-day conference by the Lebanese Society of Cardiology and the Lebanese Society of Emergency Medicine (Isma'eel et al., 2019), a Survival Chain Partners Society was developed, obtained funding from philanthropists, and distributed 20 AEDs in all governorates. However, this effort was halted following the economic crisis and the COVID-19 pandemic. The chief executive officer of a major AED supplying company reported that a number of institutions purchased AEDs from him and from other suppliers. Still, the use and experience with these AEDs have not been investigated. In Lebanon, lay people and nurses reported unwillingness to use AEDs due to their fear of legal liability (Haidar et al., 2018; Noureddine et al., 2021), and EMS personnel recommended educating the community about CPR and AEDs (Haidar et al., 2018). The purpose of this study was to describe the experience of institutions that acquired AEDs. The specific aims were to:1) Describe the frequency and management of cardiac arrests in the institution; 2) Describe employee training in resuscitation and handling of AEDs at the institution; 3) Identify the frequency of use, cost and maintenance of AEDs in the institution; 4) Identify the perceived barriers to using AEDs; and 5) Identify the predictors of perceived barriers to using AEDs.

2. Methods

This cross-sectional study used a quantitative descriptive design. A convenience sample of 75institutions that got AEDs were recruited through the chief executive officer of a major supplier of AEDs. The managers of these organizations were contacted by phone, informed about the study and invited to participate. Those who agreed were asked for an appointment for a face-to-face interview.

2.1 Procedure: The Ethics Committee of the university where the study was conducted provided approval of the study. The study questionnaire was developed in English based on the literature (Ball et al., 2022; Brooks et al., 2013). Translation from English into Arabic then back translation into English were made by a health provider and a professional translator. The two Arabic versions were compared and discrepancies were resolved by consensus. A panel of experts, including a PhD prepared nursing faculty, an Emergency Medicine specialist and a lay person, evaluated the conceptual relevance of the items and their appropriateness to the Lebanese context, and supported the content validity of the questionnaire. Pilot testing was done with five participants to ensure clarity and appropriateness of the questions to the Lebanese sample. The pilot data were not included in the main study.

A participant information form describing the study was provided to the participants, assuring them of the confidentiality of the information obtained and emphasizing the voluntary nature of participation. The interview was scheduled at a time convenient for the participants. Each interview lasted 15 to 20 minutes.

2.2 Instrument: The questionnaire included mostly multiple-choice questions. The items asked about the location and type of institution, the number of employees and whether or not the institution had a health professional on board. Awareness of the participants about CPR and AEDs was investigated, in addition to the location of the nearest hospital. The participants were asked about the frequency of cardiac arrests in their institutions, their documentation, presence of protocols for handling them and provision of CPR training to the employees. The next section asked about the location of the AEDs in the institution, training in their use, their cost and maintenance. The last section was a 5-point Likert scale (strongly agree to strongly disagree) that addressed the perceived barriers to using AEDs (Ball et al., 2022; Brooks et al., 2013).

2.3 Data analysis: The statistical package for the social sciences(SPSS) version 26 was used for data analysis. Means, standard deviations, frequencies and percent, were calculated to describe the sample and variables of interest. Medians and inter quartile range were used for variables that were not normally distributed. For aim #5, bivariate analyses, including t-tests, chi squared tests, Pearson r correlation coefficient, and analysis of variance (ANOVA) were done. A new variable (barriers to AED use) was created as the mean of the scores of the eight barrier items. The size of the organization was recorded into a dichotomous variable based on the median number of employees. A multivariable linear regression analysis was used to identify the predictors of the barriers to AED use.

3. Results

Eighty institutions were identified that had AEDs. They were contacted and 75 agreed to participate in the study (response rate 93.75%). Table 1 shows the characteristics of the organizations and participants surveyed. The most frequent type of organization was commercial companies or factories, followed by primary health care centers or polyclinics, then high schools and governmental institutions, including municipalities. The most frequent sites were in the Southern governorate, followed by the capital Beirut.

The number of employees in the organizations ranged between 3 and 1,000 employees, with a mean of 50.5 (median 45). Moreover, between 25 and 6,000 visitors came to the organizations daily, with a median of 400 visitors. The nearest hospital to the organization was on average 22.9 minutes away by car (Standard deviation = 9.76; range 5 to 45 minutes), with 29.7% reporting 20 minutes.

The majority of the interviewed participants were males (60.6%), aged 30-39 years (52%), and with a university degree (78.7%). Moreover, most participants were managers, and 40%reported that they had a health professional in their organization.

Table 1. Sample Characteristics (N=75)

Characteristic of the Organization and Participant	Frequency	Percent %
Type of Organization		
Commercial company/factory	12	16.0
Primary health care center/polyclinic	8	10.7
High school	7	9.3
Governmental institution including municipalities	7	9.3
Touristic site	6	8.0
Health charitable community	5	6.7
Restaurant	4	5.3
Mall	4	5.3
Popular market	4	5.3
Bank	4	5.3
Religious/cultural center	4	5.3
Club or gym	3	4.0
University	3	4.0
Resort/hotel	3	4.0
Airport	1	1.3
Governorate		
Beirut	17	22.7
Mount Lebanon	13	17.3
Bekaa	13	17.3
South Lebanon	20	26.7
North Lebanon	12	16.0
Number of employees in the organization (median; IQR)	45; 14, 60	
Number of visitors the organization per day (median; IQR)	400; 150, 800	
Participant gender (Male)	47	62.7
Participant Education		
Up to high school or technical	16	21.3
Bachelor's degree	35	46.7
Graduate Studies	24	32.0
Participant's age		
18-29 years	4	5.3
30-39 years	39	52.0

40 years and above	32	42.7
Participant position		
Manager	52	69.3
Director	7	9.3
Employee	13	17.3
Health professional	3	4.0
Health professional present in the organization	30	40.0

Legend: IQR=inter quartile range

3.1 Cardiopulmonary Resuscitation Results

Table 2 shows the results about the organization's experience with cardiac arrests. Only 18.7% of the sample reported having a protocol to handle arrests in the organization, and over two thirds that their first response to an arrest was calling an ambulance, with the Lebanese Red Cross the most frequently called EMS organization. In half the sample, the arrest witness was the one to call for help. The most common challenges during an arrest were delay in arrival of help, followed by lack of trained personnel in CPR, in addition to 42.7% of participants reporting more than one challenge. Only 17.3% of the sample reported keeping records of cardiac arrests.

Table 2. Experience in Cardiac Arrests and Cardiopulmonary Resuscitation (N=75)

Variable	Frequency	Percent
Protocol to handle cardiac arrests in the organization	14	18.7
First response to a cardiac arrest		
Call ambulance	49	65.3
Start resuscitation	3	4.0
Call ambulance and start CPR	23	30.6
Emergency service called for CPR		
Lebanese Red Cross	34	45.3
Civil Defense	20	26.7
Combination of emergency service organizations	21	27.9
Who calls for emergency service?		
Arrest witness	34	45.3
Employee or manager	19	25.3
Health employee	10	13.3
Security personnel	8	10.7
Whoever is available	4	5.3
Challenges during cardiac arrest		
Delay in arrival of help	26	34.7
Lack of trained personnel in CPR	14	18.7
Lack of nearby health facility	2	2.7
Reaction of witnesses	1	1.3
Combinations of the above	32	42.7
Records of resuscitation kept	13	17.3

Legend: CPR=cardiopulmonary resuscitation

Table 3 shows the results regarding CPR. The average number of arrests per year ranged between 0 and 15, with a mean of 3.2 (median 2). All the participants have heard of CPR and the majority received CPR training, but less than one third participated in resuscitation. Seventy three percent reported employee training in CPR in the organization, most often by the LRCand the Civil Defense. Most often the organization selected the trainees. All participants in those institutions where no training was done reported their desire to have employees trained in CPR.

Table 3. Awareness and Training in Resuscitation (N=75)

Variable	Frequency	Percent
Number of arrests per year (median; interquartile range)	2; 1, 5	
Received CPR training	62	82.7
Participated in CPR	21	28.0
Training of employees in CPR	55	73.3
Who does the training in CPR?		
Lebanese red Cross	27	49.1
Civil defense	16	29.1
Islamic Health Authority	9	16.4
Non-governmental organizations	2	3.6
Health manager at the organization	1	1.8
***How are the trainees selected?**		
Appointed employees	43	78.2
Volunteering employees	17	30.9

Legend: CPR=cardiopulmonary resuscitation
***Some participants reported both employees volunteering to be trained and being appointed by the administration**

3.2 Findings Related to AEDs

Table 4 shows the responses to the AED items. Most participants knew what an AED was and 81.3% received training in its use, but only 26.7% have used one.The majority of institutions got one AED, with the airport acquiring 24 devices. Onethird of the participants stated that the AED was placed in clinic or emergency room, and one fourth that it was put in the reception area or the main office. Over half of the sample reported that the AED was put under lock, with the manager keeping the keys. Fifty-eight participants (77.3%)stated that the AED should be easily accessible.

Almost half of the sample reported that they did not use the AED since it was acquired, with 40% having used it once or twice. The most frequent reasons for acquiring the AED were a medical recommendation and a donation. On the other hand, 45.3% of the sample reported that the cost of the AED ranged between 2,001 and 3,000 USD, with its maintenance most frequently costing201to300 USD.

The majority of the participants (74%) reported that there were 1 to 20employees who were trained in AED use in the institution, and 64% stated that these were trained only once. Mostorganizations did routine AED maintenance that was mostly done by the AED supplier. The supplying company provided free training in AED use in 88% of cases, and the cost of supplies was 100 – 200 USD in over two thirds of cases.

Table 4. Awareness of AEDs (N = 75)

Variable	Frequency	Percent
Knows what an AED is	73	97.3
Used an AED	20	26.7
Trained in using an AED	61	81.3
Number of AEDs in the institution		
1	71	94.7
2	3	4.0
24 (in the airport)	1	1.3
AED location in the institution		
Clinic or emergency room	25	33.3
Reception area	19	25.3
Main office	18	24.0
Security officer room	12	16.0
Airplane	1	1.3
The AED is placed in a closed area/under lock	39	52.0
Who has the keys to the AED place?		
Manager	22	61.1
Security officer	5	13.9
Health professional	5	13.9
Employee	4	11.1

Where do you think the AED should be placed?		
Easily accessible location (nearby or open place)	58	77.3
Clinic	12	16.0
Safe closed place	5	6.7
Frequency of AED use in the institution since it was acquired		
0	36	48.0
1	15	20.0
2	15	20.0
3	2	2.7
4	2	2.7
5	4	5.3
7	1	1.3
Reason for getting the AED		
Medical recommendation	29	38.7
Donation	28	37.3
Too many arrests at the worksite	18	22.7
Combination of reasons	1	1.3
Cost of AED		
No cost/donation	28	37.3
1000—2000 USD	6	8.0
2001—3000 USD	34	45.3
3001—4000 USD	3	4.0
4001—5000 USD	4	5.3
Cost of AED maintenance		
Free maintenance	13	17.3
100—200 USD	23	30.7
201—300 USD	26	34.6
301—400 USD	10	13.3
401—500 USD	3	4.0
Who got trained in AED use?		
Employees & security officer	31	41.3
Manager	23	30.7
Nurse	14	18.7
Combination of the above	7	9.3
Number of trainees in use of AED		
1—20	54	73.6
21—40	12	16.2
41—60	7	9.6
1000	1	1.4
Frequency of training in AED use		
0	5	6.6
1	48	64.0
2	20	26.7
3	2	2.7
Routine of maintenance	61	81.3
Frequency of maintenance of AED		
1	40	65.6
2	21	34.4
Who does maintenance of AEDs? (out of those who answered)		
Company	62	100.0
Cost of training		
Free training	66	88.0
50 USD	6	8.0
100 USD	3	4.0
Cost of supplies		
No cost	17	22.7
100—200 USD	49	65.3
201—300 USD	9	12.0

Legend: AED = Automated External Defibrillator

Table 5 shows the barriers to AED use. The most frequently endorsed barriers were the inability to afford the price of AED (96% agreed or strongly agreed), believing that only health professionals can operate AEDs (82.7%), and lack of awareness about AEDs (73.4%).

Table 5. Barriers to the Use of AEDs (N = 75)

Barrier	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Lack of awareness about AEDs	26 (34.7)	29 (38.7)	8 (10.7)	12 (16.0)	0 (0)
Lack of designated employees to manage the AED	13 (17.3)	18 (24.0)	8 (10.7)	29 (38.7)	7 (9.3)
Lack of confidence in using AED despite training	3 (4.0)	16 (21.3)	10 (13.3)	37 (49.3)	9 (12.0)
Inability to afford the price of AED	55 (73.3)	17 (22.7)	2 (2.7)	1 (1.3)	0 (0)
Not expecting arrests at work that warrant AED use	2 (2.7)	31 (41.3)	13 (17.3)	23 (30.7)	6 (8.0)
Believing that only health professionals can operate AEDs	41 (54.7)	21 (28.0)	4 (5.3)	8 (10.7)	1 (1.3)
Difficulty to access AED because of its location	4 (5.3)	27 (36.0)	9 (12.0)	23 (30.7)	12 (16.0)
Fear of legal persecution	2 (2.7)	16 (21.3)	21 (28.0)	28 (37.3)	8 (10.7)

Legend: AED = Automated External Defibrillator

3.3. Factors associated with the Barriers to Using AEDs

Bivariate analyses were conducted between the barriers scale and the following variables: size of the organization, presence of a health professional, whether or not the AED was under lock, frequency of training in AED use, cost of AED, the number of arrests per year, the distance to the nearest hospital and the time expected for help to arrive during an arrest. Significant associations were found between the barriers to AED use and putting the AED under lock (3.58 vs. 3.13, $p < 0.001$), frequency of training ($r = -0.27$, $p = 0.025$) and the cost of AEDs ($r = 0.25$, $p = 0.034$). The time expected for help to arrive was marginally significant ($r=0.22$, $p = 0.054$). So, the regression analysis included these variables and the findings are shown in Table 6, with 33.6% of the variance in the barriers explained by the model ($R^2 = 0.336$). The only significant predictor was having the AED under lock, which was associated with a higher perception of barriers to using the AED.

Table 6. Regression analysis for the barriers to use of AED

Variable	B	SE of B	Beta	t	P value	Lower bound of 95% CI	Upper bound of 95% CI
Constant	3.134	0.188					
Frequency of training	-0.111	0.072	-0.155	-1.541	0.128	-0.254	0.033
The AED in a closed place	0.386	0.086	0.448	4.493	<0.001	0..214	0.557
Expected time of arrival of help during an arrest	0.011	0.007	0.156	1.594	0.116	-0.003	0.025
Cost of the AED	-0.033	0.026	-0.130	-1.295	0.200	-0.084	0.018

Legend: AED=Automated External Defibrillator; CI=Confidence Interval; SE=Standard Error

4. Discussion

The study explored the organizations' responses to cardiac arrests, the challenges they face, and their use of AEDs. The sample was heterogeneous in terms of the types and size of organizations sampled and their geographic location. The average frequency of cardiac arrests per year (mean of 3.2), suggests that cardiac emergencies are not rare in these settings. Therefore, adequate preparedness and prompt response are needed in these situations. This is especially true given the distance of hospitals from these sites and the reported delay in EMS arrival as a challenge, since every minute of delay in resuscitation counts. The very small number of organizations that had a protocol to handle arrests suggests a potential gap in their emergency preparedness, since

having a clear protocol can significantly improve the chances of a successful resuscitation outcome, especially that not all employees are trained in CPR and use of AEDs. Moreover, keeping records of the arrests was reported by less than 20% of the sample; such documentation can be valuable for quality assurance and future prevention efforts. Therefore, there is room for improvement in record-keeping and post-event analysis. The results overall suggest lack of compliance with the AHA recommendations related to community public access defibrillation (Haskell et al., 2009).

The majority of participants reported calling an ambulance as their first response to an arrest. While calling an ambulance is a crucial step in providing emergency assistance, the delay in arrival of EMS necessitates immediate initiation of CPR, which highlights the importance of training employees in resuscitation. Delay in arrival of EMS to the scene of an OHCA was documented in previous studies in Lebanon due to traffic jams (Haidar et al., 2018).The fact that the arrest witness made the call to the EMS in almost half the cases demonstrates their ability to recognize an arrest, which is important for prompt resuscitation.

One resuscitation challenge was lack of trained personnel in CPR, reflecting the need for training more employees, especially in organizations where arrests occur frequently. Therefore, addressing these challenges is crucial to improving cardiac arrest outcomes in these organizations.

The majority of participants reported having been trained in CPR. This is a positive finding so they can intervene during arrests. The training was most often conducted by the LRC and the Civil defense, which are known to provide high-quality CPR training. However, given that less than one-third of those trained have actually participated in performing CPR suggests that there may be barriers against applying their skills. It may be that training was not done regularly enough to maintain competence, as was found among Lebanese nurses who work in community settings (Noureddine et all, 2021), or may be these participants did not witness arrests while on duty. In most cases, the organization appointed those who got trained. This centralized decision-making process allows organizations to tailor their training programs to their specific needs and priorities, which can be an effective approach. In those organizations that did not provide CPR training, the reported desire to train employees in CPR demonstrates their willingness to improve emergency preparedness.

Over 80% of participants were trained in using AEDs, which is reassuring, but less than one third reported having used it. This may be either due to infrequent exposure to an arrest while on duty, or the low frequency of training in AED use, as 80% reported receiving training only once or twice. Regular training in AED use is very important to improve skill acquisition and retention (Yeung et al., 2011). Over half of the AEDs are placed under lock and managers have the keys; while this practice may be driven by security concerns, it may reduce the accessibility to the AEDs during emergencies. The AEDs were most often either recommended by a physician or acquired as a donation. In the absence of a national PAD program, their use will remain limited. Regular training and mock codes can reinforce employees' awareness of the importance of AEDs as tools to save lives, maintain their competence in their use and subsequently increase their confidence during arrests.

The most frequent barrier to the use of AEDs was the inability to afford their price. The cost of AEDs and their maintenance can be a significant financial burden, especially for small organizations and those with limited budgets. Addressing this barrier may involve seeking funding or working with suppliers to get discounts. With 37% of institutions receiving the AED as donation, relying on philanthropists is not enough; the government needs to provide such devices for successful resuscitation in public places.

The belief that only health professionals can operate AEDs was the second most common barrier. Educating individuals that AEDs are user-friendly and anyone trained can effectively operate them can help alleviate this barrier. The third barrier was lack of awareness about AEDs, suggesting that many individuals within these organizations may not fully understand what AEDs are, how they work or their role in cardiac arrests. Organizations should provide comprehensive training using simulations and drills, and education to dispel misconceptions about AEDs. To promote the accessibility of an AED, the device must be easy to reach within the organization, as recommended by 77% of the sample. Overall, overcoming these obstacles is crucial for increasing the chances of effective AED utilization during cardiac emergencies and for fostering a culture of safety and preparedness in the workplace.

The multivariable regression analysis revealed that placing the AED under lock predicted a higher perception of barriers to AED utilization. Therefore, the AED ought to be placed within easy reach. Other relevant predictors such as frequency of training and expected time of arrival of EMS during an arrest did not reach statistical significance possibly due to the limited sample size. Still these factors cannot be ignored, given their importance, especially in places with no nearby hospitals or EMS agencies.

5. Conclusion

In conclusion, despite some success in providing AEDs in public places, Lebanon is a long way from having an organized sustainable PAD program. In a country where natural and man-made disasters are abundant, the need for emergency preparedness cannot be over emphasized. Meanwhile, making AEDs available and accessible, and regular training in their use can help improve the outcomes of OHCA victims at work and other public places.

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HM, AA and SN conceptualized, developed and supervised the study. HM and SN cleaned and analyzed the data and interpreted the results. SZ contributed to the write up of the manuscript. All authors approved the final version of the manuscript.

Conflict of Interest:

The authors declare that they have no conflict of interest

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