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Cardiac arrest corner

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Challenges in Mexico in the management of out-of-hospital cardiac arrest

Retos en México en el manejo del paro cardiaco extrahospitalario

Jorge Álvarez de la Cadena-Sillas,* Enrique Asensio-Lafuente,‡ Juan Manuel Fraga-Sastrias,§ Humberto Rodríguez-Reyes,¶ Agustín Ramiro Urzúa-González,‖ Edgar Díaz-Soto**

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Keywords: sudden cardiac death, out of hospital cardiac arrest, hands only cardiopulmonary resuscitation, public access defibrillation, automatic external defibrillators.

Palabras clave: *muerte súbita cardiaca, paro cardiaco extrahospitalario, resucitación cardiopulmonar sólo con las manos, desfibrilación de acceso público, desfibrilador externo automático.*

ABSTRACT

Sudden cardiac death (SCD) and out-of-hospital cardiac arrest (OHCA) are global health problems that are responsible for almost 30% of cardiovascular deaths. The implementation of the chain of survival, including hands-only cardiopulmonary resuscitation (CPR) and early defibrillation, has improved survival and prognosis for OHCA patients. This work reviews the challenges and opportunities in Mexico regarding various strategies applied in recent decades to improve the survival rate of sudden cardiac arrest through the timely administration of CPR and early defibrillation. Interventions such as Public Access Defibrillation (PAD), volunteer responder programs, mobile dispatch of Automatic External Defibrillators (AED), drone delivery of AEDs, or new technologies for early detection of cardiac arrest are analyzed in the Mexican context.

RESUMEN

La muerte súbita cardiaca (MSC) y el parocardiaco extrahospitalario (PCEH) son un problema de salud mundial, responsables de casi el 30% de las muertes por causa cardiovascular. La implementación de la cadena de supervivencia, incluida la reanimación cardiopulmonar (RCP) sólo con las manos y la desfibrilación temprana, ha mejorado la supervivencia y el pronóstico de los pacientes con OHCA. El presente trabajo revisa los desafíos y oportunidades actuales en México respecto de diferentes estrategias que se han aplicado en diferentes países en las últimas décadas, para mejorar la supervivencia del paro cardíaco súbito mediante la administración oportuna de RCP y desfibrilación temprana. Se analizan en el contexto mexicano intervenciones como la desfibrilación de acceso público (PAD), los programas de respuesta voluntaria, el envío de desfibrilador externo automático (DEA) móvil, la entrega de DEA con drones o las nuevas tecnologías para la detección temprana de paro cardiaco.

Abbreviations:
AED = Automatic External Defibrillators
ByDef = Bystander Defibrillation
CA = cardiac arrest
CPA = Cardio Protected Areas
CPR = Cardiopulmonary Resuscitation
CRUM = Centro Regulador de Urgencias Médicas
EMS = Emergency Medical System
OHCA = Out-Of-Hospital Cardiac Arrest
PAD = Public Access Defibrillation
RENAPACE = Registro Nacional de Paros Cardiacos Extra Hospitalarios
ROSC = Return to Spontaneous Circulation
SCD = Sudden Cardiac Death
T-CPR = Telephone-guided CPR
VF = Ventricular Fibrillation
VRP = Volunteer Responder Program

INTRODUCTION

Out-of-Hospital Cardiac Arrest (OHCA) and Sudden Cardiac Death (SCD) are world health problems, accounting for around 30% of total cardiovascular mortality and nearly 20% of all deaths in adults. The one-year survival rate for OHCA is low, around 8-10%.[1-3] In México, an estimated 33,000 SCD cases occur each year, although the lack of precise information

* Médico Cardiólogo, Práctica Privada San Miguel Allende. Cardiólogo del Instituto de Corazón de Querétaro. México. ORCID: 0009-0009-5461-6154
‡ Médico Cardiólogo y Electrofisiólogo, Instituto de Corazón de Querétaro. México. ORCID: 0000-0003-4833-2664

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§ Médico Director Cáncer Center. Querétaro, México. ORCID: 0000-0002-9255-278X
¶ Médico Cardiólogo y Electrofisiólogo Sociedad Cardiovascular y Arritmias. Aguascalientes, México. ORCID: 0000-0003-3164-8515
‖ Médico Cardiólogo, Unidad de Cuidados Intensivos del Hospital Regional de Alta Especialidad del Bajío. León, Guanajuato, México. ORCID: 0000-0002-9403-0686
** Médico Especialista en Medicina de Urgencias. Hospital General de Zona, Unidad Médico Familiar No. 8 del Instituto Mexicano del Seguro Social. Ciudad de México, México. ORCID: 0000-0002-6979-6794

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may underestimate this figure. At least half of these events happen outside a hospital or medical facility.[4,5]

Early cardiopulmonary resuscitation (CPR) by laypersons (bystander CPR, B-CPR) and the use of an Automatic External Defibrillator (AED) before the arrival of the Emergency Medical System (EMS) may increase the survival rate.[6-9] The implementation of the survival chain in any SCD event is vital. This survival chain implies simple and useful maneuvers and concepts that require coordination in each action. To be successful, CPR during an OHCA involves the intervention of a community trained in hands-only CPR.

They can activate the first three steps of the survival chain by detecting the OHCA, notifying the EMS, starting hands-only CPR, and, if necessary, using the AED.[10,11] Hands-only CPR and early on-site use of AED may increase survival rates from 50 to 74%,[12-14] thus reducing the incidence of SCD; nonetheless, most OHCAs occur at the patient's home or working places, where the victim might be alone, and access to early defibrillation is low.[15-18]

The creation of Cardio Protected Areas (CPA) in Mexico requires early public access to defibrillation as a priority mechanism for treating SCD and involves training laypersons and other non-medical personnel, who are usually the first to intervene during a cardiac arrest (CA). They must be able to start the chain of survival, establishing basic and efficient hands only CPR until they or the EMS use an AED on the scene.[19,20]

In this paper, we analyze international recommendations and various approaches to achieve early defibrillation and improve OHCA survival. A perspective on the current state of the matter is offered, and the challenges in OHCA and SCD in Mexico, and what is currently being implemented, are depicted.

PUBLIC ACCESS DEFIBRILLATOR

Public access defibrillator (PAD) is probably the first and simplest strategy to prevent SCD and treat OHCA in many countries.[21-26] In Mexico, the first PAD program began in San Miguel de Allende, Guanajuato, in 2013.[27] Since then, several cities and states around the country have installed AEDs in public areas.[28-30] Latin American countries, such as Colombia, Panamá, Uruguay, and Chile, which are considered low- to medium-income, have also made scattered efforts to achieve successful PAD programs. However, perhaps Brazil pioneered a large-scale intervention program in Sao Paulo. They installed AEDs in the city's subway and trained the station personnel to administer CPR and use the AED. The initial return to spontaneous circulation (ROSC) did not increase significantly, but one-year survival reached 43% in treated patients.[31,32] In Spain, a high-income country, the concept of PAD involves areas with a high risk of OHCA. AED installation is mandatory in towns with more than 50,000 inhabitants and in public facilities, such as sports centers or complexes, with a daily capacity of 500 or more persons. It is also required by law for public establishments with a capacity of 5,000 or more people and subway stations with an average daily influx of 5,000 or more people. Other venues include large commercial centers, airports, bus and railway stations, and establishments with an average daily influx equal to or greater than 1,000 users, and centers or complexes with 500 users. In schools, work centers with more than 250 people, hotels with more than 100 beds, and residential centers for the elderly with more than 200 places, AEDs are also required.[33] This PAD strategy, along with a high rate of witnessed OHCA, By-CPR, and early defibrillation has increased survival rates up to 74 to 100% in patients with a witnessed arrest and an initial shockable rhythm such as ventricular tachycardia or fibrillation.[34,35] In such scenarios, the probability of bystander defibrillation (ByDef) can be increased by up to three times, and if the OHCA occurs near an accessible AED, survival rates can double.[36,37] The distribution of resources in Mexico and similar countries is hardly attainable due to geographic, economic, and social limitations. A targeted program like the one developed in Sao Paulo, based on population studies identifying high-risk areas and facilities, can optimize the distribution of AEDs and hands-only CPR training efforts.

Another issue that must be addressed is that most OHCA do not occur in high-person-flux areas but in places without a nearby AED or easy access.[38] In contexts such as residential areas, where OHCA and SCD occur more often, the probability of ByDef is very low, even when an AED is on-site.[39,40] A possible solution is the inclusion of other first responders, such as hands-only CPR-trained police officers with AED-equipped patrol cars, that might have an early arrival on-scene,[41] (discussed later), and telephone dispatch-guided CPR by family or on-site persons.

Although the Centro Regulador de Urgencias Médicas (CRUM) of Querétaro City has begun implementing that assistance, implementation has been inconsistent, and no measurable results have been achieved (non-published information).

It has been proven that PAD with on-site AED offers high survival rates, but also a very low coverage of patients since OHCA is more likely to occur in the victim's house. In countries like México, the financial cost of providing large numbers of AEDs will likely lead to excessive expenses and low efficacy. Only a few CA or OHCAs are covered by PAD programs with an AED on site, and private homes, where most events take place, are poorly covered by these devices. Efforts must be directed towards early OHCA recognition and EMS activation, community hands-only CPR training, and the use of AEDs. A smartphone application to identify the location of the nearest available AED can be helpful in residential areas to shorten response times.

A few Mexican states have approved laws to support and accelerate the establishment of cardio-protected areas, with limited success so far, despite the publication of a certification protocol two years ago.[42-44] The states of Sonora, Coahuila, Sinaloa, Jalisco, Morelos, and Yucatán have passed a Cardioprotection Law, and bill initiatives have been presented to Congress in Chiapas, Guerrero, Mexico City, Oaxaca, and Querétaro. There are other states and cities where isolated efforts have been made to implement cardio-protected spaces (for example, Aguascalientes, Durango, Hidalgo, Nayarit, Puebla, San Luis Potosí, Tamaulipas, and Tijuana).[5] Regarding the federal legislation on cardio-protected areas, on March 14th, 2013, the General Health Council issued an agreement published in the Official Gazette of the Federation, which urges owners and those responsible for establishments to have an AED in their facilities.[43-45]

On September 21st, 2021, after approval by the United Commissions on Health and Legislative Studies, the initiative was presented and approved in the Senate of the Republic as a reform to the General Health Law to prevent SCD. The draft decree was sent to the Chamber of Deputies for the purposes of Article 72 of the Constitution.[46] In this regard, another challenge is to optimize and clarify legislative work and resolutions (in the form of laws, codes, or regulations) at the municipal, state, and federal government levels. It needs a coordinated effort from society, medical societies, and non-government organizations to reach political representatives and establish proper communication channels. Furthermore, the same civil organizations and the public must have the legal certainty and protection to teach and implement nationwide hands-only CPR programs that include PAD. The Asociación Nacional de Cardiólogos de México (ANCAM) has just started a free Hands-only CPR training program for laypersons and the public interested in the topic. In this regard, scientific societies with an educational vocation might also join efforts to reach a broader population and raise awareness.

Figure 1 summarizes the key points of a PAD program.

THE REGISTRY

An official report in Mexico by the National Institute of Statistics and Geography (INEGI, its acronym in Spanish) indicates a mortality rate for cardiovascular disease, not linked to gender, close to 20% in our country. This report demonstrates that from the first week of 2020 to week 25 of 2021, the expected mortality from cardiovascular diseases was 232,658. Unfortunately, in Mexico, due to the lack of statistics and information, many SCDs are not reported in the death certificate as the leading cause and appear, instead, as if acute myocardial infarction was the direct cause

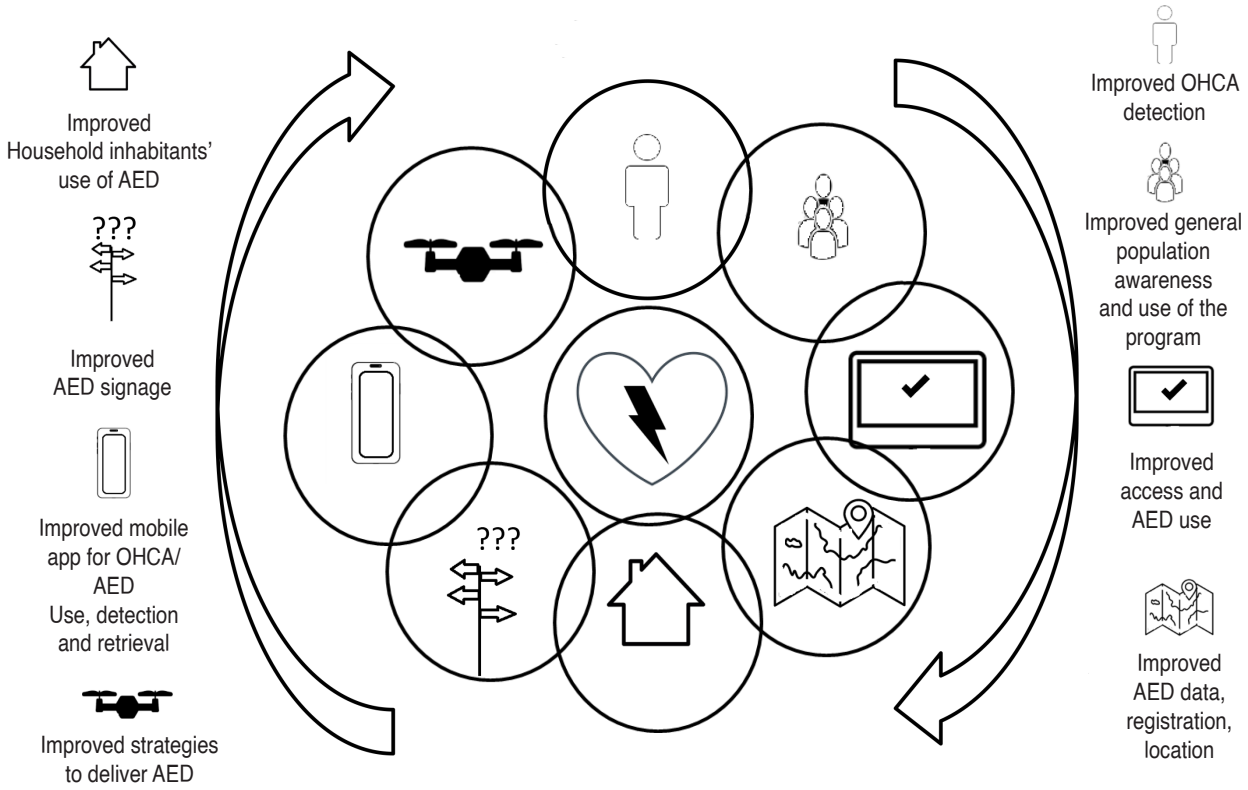

Figure 1: Public access defibrillation scheme.
Modified from: Folke F et al.[73]
AED = Automatic External Defibrillators. OHCA = Out-Of-Hospital Cardiac Arrest.

of death. These are two related but different clinical entities, especially in the case that concerns us (SCD), for treatment, statistics, research, and improvement of public health. In general, if statistics do not reveal SCD as the real cause of death, SCD will not be recognized as a public health problem. Thus, it will not have a tangible impact on public decision-making regarding intervention. The death certificate must be correctly completed so it can be used to evaluate health needs, as previously mentioned. They consist of research, planning, and monitoring of public health policies.[47,48]

A suggested protocol for certifying cardio-protected areas in Mexico has been published as described earlier.[42] An Out-of-Hospital Cardiac Arrest Registry (Registro Nacional de Paros Cardiacos Extra Hospitalarios, RENAPACE, its acronym in Spanish) should be the first step toward improving SCD mortality in Mexico.[42] RENAPACE should be a national public health policy involving complete pre-hospital EMS. Not only does it measure the outcome (life or death) of the OHCA event but also the aspects related to the initial CPR treatment, for instance, if B-CPR was performed, the number of pauses and quality of chest compressions, the initial heart rhythm, and successful cardiac shock by an AED, this information will tell what parts of the CPR and chain of survival could be improved. The program should have sufficient resources and the full support of the public and private health system administration, politicians, and medical and paramedical associations.[49] Resources, including administrative and medical personnel, will collect information from OHCA reports, ideally including dispatch center records, AED records database, hospital records, and the new entity, SCD, to be included in the death

certificates. Emory University did an example of this on the CARES Project.[18]

Other important variables to include in the RENAPACE would be total population, OHCA survival rate for all the rhythms, with special focus on patients treated for ventricular fibrillation (VF), discharged alive after an OHCA, neurological outcome evaluation, witnessed OHCA and B-CPR, Telephone-guided CPR (T-CPR), time of CA to call to dispatch center, time from CA to first compression for T-CPR, and time from collapse to EMS arrival (estimated or witnessed). Other variables can be included, among them, AED's location, time of EMS to start CPR and PAD, and first responder CPR with the use of AED before the EMS arrival, including the police department, first rhythm obtained, if it was a shockable rhythm, and time to first defibrillation. Trauma patients should be excluded from the registry.

IMPLEMENT A TELEPHONE-GUIDED CPR (T-CPR) CENTER WITH ONGOING TRAINING

This intervention relies entirely on the municipal government and should be coordinated with the 911 service. Several municipalities or states have recently tried implementing a CRUM to optimize emergency medical services deployment. In 2022, there were 156 CRUM nationwide; however, there are several disparities in the required degrees and experience to work in such centers. A telephone dispatch center with dispatcher-assisted CPR protocols should be implemented. It is difficult for telephone dispatchers to recognize a CA in the context of an OHCA by telephone, and it is even more challenging and demanding to provide CPR instructions. Ideally, this telephone call should be recorded and reviewed to gather feedback from individual dispatchers and the entire team, identifying how the service could be improved (e.g., how OHCA recognition could be completed faster and more effectively).[50,51] The dispatcher should have a professional and psychological profile (or training) to fill this position. The national medical associations could assess the dispatch center's training to improve the center's quality, evaluation, and service. Some initiatives and municipalities have tried to start this type of program in México; however, there is no proposal at the federal level that includes the entire country for its implementation. Special legislation to support this program is needed in the country.

VOLUNTEER RESPONDER PROGRAM (VRP)

Another strategy that has shown benefits in locations where geographic or financial reasons might limit PAD programs is the Volunteer Responder Program (VRP). Volunteer personnel from different organizations are contacted via a mobile app or smartphone from the dispatch center and directed to the victim, with information about the nearest available AED. This kind of intervention, initiated 15 years ago in Scandinavian countries, is trying to reduce gaps with PAD.[52,53]

The VRP tried to increase CPR and Bystander defibrillation administration before the EMS arrived at the scene. Several studies have found that VRP is associated with increased B-CPR and early defibrillation rates.[54,55] VRP significantly reduced the time to first defibrillation, increased B-CPR, and improved survival for patients with a shockable rhythm.[56] Activation of the VRP could have a greater impact on patient survival in areas with long EMS response times (e.g., rural areas or crowded cities such as Mexico City, with an average response time of 30 to 50 minutes, according to several public sources).

Local volunteers can get to the victim more quickly with an AED. Nonetheless, the positive results will rely on addressing different aspects: the EMS dispatcher must recognize the emergency call as a potential OHCA, activate the professional EMS system, and activate the VRP. The VRP needs to have enough volunteer responders and precisely know the location of the nearest available AEDs in all areas where OHCAs occur.[57]

Implementing a VRP requires an AED location registry accessible to the emergency dispatch center and specialized software or communication tools to activate volunteer responders in a timely manner. This program can potentially increase B-CPR and defibrillation,

but further investigation is needed, especially to determine survival rates.[58]

No VRP program has been implemented in Mexico. If it was to be done, it should probably be done after PAD had succeeded. Several barriers are perceived in this matter: legislation must be implemented, as with the PAD programs, to establish VPR reach and limits, protect volunteer personnel, determine the certifications they need, and so on.

Social issues must be faced: safety is a primary concern in many regions in Mexico. Some paramedics have tactical formation, but volunteers and laypersons do not: they should be able to administer first aid without concern for their own safety, and legal and social measures must be in place.

A variant of VRP could include other emergency service providers in the system, such as firefighters or police officers. A study by Aguilera et al. used the Hauswald methodology[59] to estimate the costs of shifting the first response to an OHCA from EMS to police units.[41] According to the city study, the yearly cost of saving a life with an ambulance might be from 5.8 to 60 million pesos. If the term «ambulance» is changed to «police vehicle», the estimated costs go to 0.5 to 5.5 million pesos for a saved life yearly.

Training police officers as OHCA first responders is already a worldwide recommendation,[60-65] positively impacting early B-CPR administration, survival, and cost reduction. Training the police might be a challenge in Mexico for several social and practical reasons: the EMS system is fragmented, and there is little continuity between the actions of first responders, ambulance personnel, and hospital staff. The implementation of the CRUM is slowly improving the coordination between EMS components and other emergency services, but there is still a long way to go to avoid the influence of government changes and other political conditions.[66]

There is little information on OHCA survival in Mexico, but a rough estimate is that it is nearly 0%.[41] These numbers are due to prolonged emergency services response times, especially when activating the EMS (time from collapse to EMS call), the reduced number of medical interventions, even CPR, and a general lack of knowledge about SCD and CPR. A continuous improvement program for pre-hospital emergency services and implementation of permanent educational programs for the public regarding hands-only CPR, OHCA recognition, and EMS activation are essential interventions.

In this regard, the need for a national cardiac arrest and sudden cardiac death registry in Mexico has already been addressed, along with the use of recorded AED data. In conjunction, this information might allow us to establish proven strategies to address OHCA or to design novel ones adapted to local needs.

Volunteer Responder Programs have great potential to improve B-CPR initiation and AED use, but they need technological tools to make them more efficient and to measure their results objectively.

DISPATCH OF MOBILE AND DRONE DELIVERY AEDS

The goal of reducing OHCA mortality and, thus, the burden of SCD requires, among other measures, substantially reducing response times. Professional first responders (PFRs), such as police officers, firefighters, or off-duty healthcare personnel, represent a valuable means to increase the likelihood of CPR and early defibrillation.

PFR and VRP can provide AED coverage in areas where an AED is not on site, and they can also arrive at an OHCA scene before the EMS, with an average survival rate to hospital discharge of 28.6% (range 9 to 76%).[67] *Figure 1* addresses this issue. Some European countries have implemented PFR programs and have found higher rates of return of spontaneous circulation (ROSC) and survival to hospital discharge,[62] but the effect on 30-day survival has not been demonstrated.[54]

A trial that recruited taxi drivers found very low acceptance of messages asking to act as first responders: 0.4% of the alerted ones arrived on the scene before EMS.[68]

In Mexico, this program is unavailable, and only local municipal efforts (Querétaro) have explored recruiting PFRs, with promising initial results. However, the general implementation has seen little success.[69] This probably relies on

the legal voids beginning to be filled with the above-mentioned legislation.

Figure 2 shows the success and survival rates for different CPR and AED strategies.

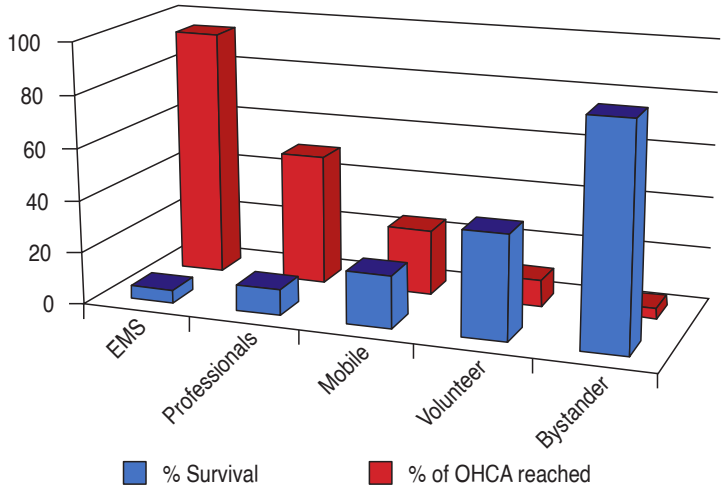

Figure 2: Accessibility and successful rates for different strategies of cardiopulmonary resuscitation and the use of automatic external defibrillators. EMS = Emergency Medical System. OHCA = Out-Of-Hospital Cardiac Arrest.

Table 1 summarizes the advantages and disadvantages of the different CPR and AED use strategies.

Implement a mandatory program to teach CPR and AED use from elementary school to the general population.

Mandatory CPR/AED training is part of the school curriculum in Norway and Denmark. Some states in the USA have legislation requiring compulsory high school CPR/AED training, but a community program, including public employees, is needed to teach CPR to the general population.[70] To obtain a driving license, a CRP course should be required, and it could be directed and supervised by Mexican Medical Organizations like ANCAM, following international medical standard protocols and guidelines. The current practices are based on international guidelines issued by ILCOR and its associates (the American Heart Association and the American College of Cardiology), although they are partial and incomplete. However, the local implementation of these programs does not require the endorsement of a foreign

Table 1: **Summary of the different strategies of cardiopulmonary resuscitation and use of automatic external defibrillators.**

Strategy	Advantages	Disadvantages
• Public access defibrillation • AEDs on site	• Rapid defibrillation • High survival rates	• Small impact on survival in private homes • Difficult predict high-risk areas to place AED • Need a big number of AED
• Volunteer responders AEDs on site	• Better defibrillation rates when arriving before EMS • Better defibrillation rates in private homes • More use of on-site AEDs because been transported to the OHCA	• Big number of volunteer responders and AEDs • Need an AED register and dispatched center
• Professional first-responders (e.g. police officers) firefighters	• Stations widely spread throughout the community • Trained in CPR and AED • Able to enter private homes	• Can be occupied by other jobs and may leave the scene if dispatched to another incident • Only effective if arrival before EMS
• Drone-delivered AEDs	• AED drone can cover a large area • Volunteers can move directly to the OHCA location while the drone delivers the AED • Fast AED delivery before EMS arrival • Very useful in in rural/and difficult access areas	• Legislation problems • Needs a trained pilot • High cost • Limit used in in with strong winds or • Heavy rain

AED = Automatic External Defibrillators. CPR = Cardiopulmonary Resuscitation. EMS = Emergency Medical System. OHCA = Out-Of-Hospital Cardiac Arrest. Modified from: Folke F et al.[73]

society. National medical associations have the authority to advocate for these programs and legislation to enable state and federal authorities to establish the necessary legal frameworks. The more people know how to perform CPR and feel protected by the law, the higher the reduction in SCD/OHCA mortality rate could be expected.[71] As mentioned earlier, in Mexico, the ANCAM is starting a free educational program to teach hands-only CPR to the general population.[72]

INTERDISCIPLINARY WORK

SCD involves a complex interplay of factors; therefore, an urgent call for a clinical multidisciplinary approach, including the three levels of government, private initiative, medical associations (at all levels of education), and EMS (including police), are essential to address this national health problem. The development of specialized sudden cardiac arrest care teams is required to ensure care, teaching, and research on SCD. There is a lot to do in Mexico, where international recommendations cannot practically be applied because the required public health programs to prevent sudden death and OHCA are not yet in place or are only beginning to be implemented in specific areas where isolated efforts have been made.

Above all, legislation that supports the eight points mentioned is needed. The implementation might be complex, and joint efforts are required from government agencies, NGOs, various authorities, and medical associations specializing in the area overseeing their regulation and implementation. It requires hard work that will take time and strong determination to complete, as well as direct financial support. Without the law's mandatory nature, these efforts might prove futile. An ongoing implementation can use the examples from other countries and adapt these points to the possibilities of our country and population. Otherwise, efforts will remain isolated and not be implemented.

CONCLUSIONS

Many efforts worldwide have been made to establish cardio-protected areas through various strategies that employ different tools and imply different approaches tailored to specific cultures, societies, geographies, politics, medicine, and other considerations. However, every approach relies on early CPR and AED use, known measures to improve OHCA survival.

Every intervention depicted in the present paper requires a precise sequence of actions based on the «Chain of survival» and almost perfect timing to achieve recovery from sudden cardiac arrest. If a PAD program is not in place, VRP and mobile AED systems will have limited success. Other interventions (drone delivery of AEDs or OHCA detection using electronic devices) will also need to have a solid PAD program to increase the chances of success in reversing cardiac arrest.

Thus, PAD in Mexico, with emphasis on hands-only CPR and early defibrillation combined with other CPR strategies, as mentioned before, needs significant efforts from the government and civil institutions to set and implement the proper legislation, define and implement educational and training activities, initiate, protect and supervise the corresponding actions, and follow up the results to establish continuous improvement programs so the medical and social burden of sudden cardiac arrest and death can be reduced to a minimal.

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Correspondence:
Jorge Álvarez de la Cadena-Sillas
E-mail: jalvarezdelacadena@gmail.com