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The dramatic increase in sudden cardiac deaths and the alarming low survival: A global call to action to improve outcome with the engagement of tertiary education system

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Abstract:

The number of out-of-hospital cardiac arrests, cause of disability and death, has dramatically increased worldwide, but despite the progress, the incidence of survival does not appear to have increased significantly. Bystander cardiopulmonary resuscitation (CPR) remains the principal factor in saving out-of-hospital cardiac arrest victims. Analyzing the immense efforts produced by states and professional organizations to train people in CPR skills for immediate intervention in the occurrence of a cardiac arrest, the primary global strategy is centered on CPR education and training for schoolchildren. But the rate of CPR training remains low, with wide differences among communities. The concept of CPR training for schoolchildren to increase bystander CPR rates needs to be implemented. We suggest a global call to action for the tertiary education system for CPR learning and training, including all undergraduate students regardless of the degree course, as a possible method to improve the traditional CPR training today centered on the secondary education system. Extending CPR training courses to the university educational system could significantly increase the number of people educated in life-saving maneuvers. The final objective is to improve the survival rate of patients with out-of-hospital primary cardiac arrest, which has dramatically increased worldwide.

Keywords:

Cardiac arrest, cardiopulmonary resuscitation, education, university

Introduction

Out-of-hospital cardiac arrest (OHCA) remains a significant, shared, and devastating cause of disability and death worldwide.^[1,2] The International Liaison Committee on Resuscitation (ILCOR) has estimated that the annual incidence of emergency medical services (EMS) treating OHCA is between 30 and 97.1 individuals per 100,000 population.^[3]

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However, based on reports from registries for cardiac arrest monitoring in various countries, researchers have outlined that the incidence of OHCA has dramatically increased in recent years. OHCA has risen from 62.2 to 88.8 individuals per 100,000 inhabitants in the USA.^[3,4] The increase also includes some European countries such as Denmark and Norway that have gone from an estimated incidence of

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EMS-treated OHCA per 100,000 population, respectively, of 72 and 47.9 to 81 and 78.^[3,5,6]

Main factors that contributed to increasing the number of OHCA cases

Epidemiologists' attention has focused on two plausible causes of increased OHCA.

The first is the COVID-19 pandemic factor. It has been noted that incidence and mortality following OHCA have been higher during the COVID-19 pandemic^[7-9]; variations in resuscitation practices during the pandemic could be a contributing cause,^[8] a factor that could also explain the decline in OHCA survival in 2020 in regions/time frames that did and did not have significant COVID infection rates. Patients with confirmed or suspected COVID-19 should receive the best resuscitative efforts possible. We must be committed to training healthcare providers and rigorous evaluation of the evidence to ensure our cardiopulmonary resuscitation (CPR) and First Aid guidelines support best practices.^[10]

Interestingly, the increase in OHCA cases has also been correlated to bacterial infections resistant to antibiotics. In 2019 alone, 1.27 million people died, but it seems that bacterial infections resistant to antibiotics have played a key role in 4.95 million deaths in the last few years.^[11] In Europe, about 40,000 deaths yearly are due to infections that commonly used antibiotics cannot eradicate. The prevalence of bacteremia among OHCA patients in hospital emergency departments was 46.5%.^[12] Furthermore, it has been estimated that in 2050, these deaths could arrive at several million.^[11]

Importance of early, high-quality cardiopulmonary resuscitation

Conventional CPR is today considered the gold standard primary cardiac arrest treatment, including chest compressions, rescue breathing, and an automated external defibrillator (AED).^[2]

CPR should be started as soon as possible since early initiation is directly related to survival rates.^[13,14] High-quality CPR is also fundamental in cardiac arrest care and is considered a factor affecting survival that is often overlooked.^[15,16] High-quality CPR includes five critical components^[17]:

- a. Providing compressions of adequate depth;
- b. Providing compressions of adequate rate;
- c. Minimizing interruptions in chest compressions,
- d. Avoiding leaning between compressions;
- e. Avoiding excessive ventilation.

In particular, chest compression depth is considered the most important component of CPR, with a strong

association between survival outcomes and increased compression depth.^[18] However, a complete list of components for high-quality CPR should include complete chest wall recoil after sternum compression since it improves hemodynamics during CPR by generating relatively negative intrathoracic pressure and thus draws venous blood back to the heart, finally providing cardiac preload before the next chest compression phase.^[19,20]

Recently, the American Heart Association, along with the American Academy of Pediatrics, the American Association for Respiratory Care, the American Society of Anesthesiologists, and the Society of Critical Care Anesthesiologists, has provided the most up-to-date evidence-based guidelines on resuscitation and supporting healthcare providers that deliver these interventions in the case of a pandemic, suggesting specific additional resuscitation strategies to maintain high-quality standard during CPR.^[21]

CPR training in schools

Hence, early bystander CPR is essential for survival from OHCA and can improve the chances of survival two- to threefold.^[22-24] Most of the population should be aware of, or trained in, CPR for its immediate performance by bystanders in cardiac arrest. Despite professional organizations producing immense efforts to train laypeople in CPR skills, this objective still needs to be achieved, and the rate of CPR training still needs to be higher, with vast differences across communities.^[25] Globally, the median percentage of laypeople trained in CPR is 40%, but for high-income countries, the median rate is twice as high as that of upper-middle-income countries (50% vs. 23%).^[26] Different strategies have been used worldwide to improve the rate and quality of CPR training.

It has recently been stated that several practical possibilities exist to increase lay CPR rates worldwide. One of the best and most sustainable ways is to improve mandatory nationwide CPR education for schoolchildren.^[27]

Since OHCA is witnessed in 50–80% of cases,^[28-30] but CPR by a bystander is delivered in less than 1 out of 5,^[31] increasing the rate of bystanders trained for resuscitation should improve survival. Thus, providing all schools worldwide with a mandatory CPR education program should lead to a marked improvement in global health within a few years. CPR education in schoolchildren successfully increases their knowledge and skills, facilitates the development of this psychomotor skill, and strengthens their self-confidence in helping OHCA patients.^[32,33] As stated by Böttiger et Colleague, just like swimming, playing an instrument, or riding a bike,

schoolchildren will never forget and will remember how to save a life.^[34,35]

It has long been hoped that each country's responsible Ministry of Education would implement a nationwide program for educating high school pupils and teachers to be trained in CPR to become fully competent.^[34-36]

A few years ago, the World Health Organization (WHO) endorsed a worldwide schoolchild training program in CPR called "Kids save lives."^[37] As a result of the WHO endorsement, in some regions, CPR education has been effectively included as an elementary education curriculum in primary and secondary schools. However, in others, it remains facultative. In many other areas, CPR training is only proposed as optional upon payment.

In the USA, the American Heart Association has advocated compulsory resuscitation training in American schools since 2011.^[38] Today, in the face of more than 350,000 people suffering an OHCA, 38 states and Washington D.C. have passed laws or adopted curriculum changes requiring hands-on, guideline-based CPR training for high school graduation.^[39] High school pupils are currently the largest group of individuals in the US receiving CPR training every year.^[40]

When the legislation is implemented, nearly 2.3 million public school pupils will be trained nationwide in CPR each year.^[41] In the USA, states that have integrated resuscitation into school educational programs report significantly higher resuscitation rates.^[31,42]

In **Australia**, every year, 25,000 individuals experience a cardiac arrest: 40% receive bystander CPR before the ambulance arrives, 2% receive community defibrillation, but only 12% of Australians in cardiac arrest survive.^[43] Currently, half of all Australian adults are trained in CPR.^[44]

The Australian Resuscitation Council supports CPR as the most excellent chance of survival. Key stakeholder organizations believe that the best way to ensure all Australians know how to save a life is by mandating CPR education and training in schools.^[45] The Australian school curriculum states that children in years 9 and 10 should be able to plan, rehearse, and evaluate options for managing situations where their safety or that of others may be at risk, including CPR and first aid; however, even though the curriculum for education in Australia is set at a national level, the delivery of the curriculum is decided upon by State and Territory curriculum authorities, having regard to local contexts and individual teachers' professional knowledge: There are no guarantees that a child will be taught CPR skills during schooling.^[45]

In **Europe**, the European Resuscitation Council (ERC) shares the theory that educating all school children should be the essential step for increasing the rate of bystander resuscitation and improving survival after OHCA, finally leading to a marked improvement in global health.^[46] This could be easily obtained by educating pupils beginning at the age of 12 years and for just two hours per year.^[38,42,47,48] For the ERC, pupils and teachers are essential "multipliers" in private and public settings. Thus, in the longer term, the proportion of trained individuals in society will markedly increase, leading to an increase in the overall rate of lay resuscitation.^[46]

The ERC also developed a list of 10 principles as an action framework for the education of teachers and schoolchildren in CPR, consisting of a two-step CPR approach, firstly by teaching "check-call-compress" and secondly by teaching ventilation and the use of AED.^[36,46,49-52]

However, in Europe, after three years of implementation following the WHO endorsement of the schoolchild training program "Kids save lives," education in CPR has been legislated on in five countries and is only a suggestion in 23 countries.^[53] In countries with legislation, the main focus for education was: primary schools - 20%, secondary schools - 40%, and primary/secondary schools - 40%; In countries without legislation, the preferred target was primary schools - 45%, secondary schools - 32%, primary/secondary schools - 14%, and unclear in 9% of cases.^[53]

Benefits and limits of training CPR in schools

The benefits of CPR for schoolchildren are well known, as well as the significant progress in schoolchildren's CPR knowledge, awareness of the responsibility of helping others, and increased self-confidence in providing bystander CPR.^[54] Therefore, training schoolchildren to perform CPR has been indicated as one possible method of increasing bystander CPR rates.^[47]

Despite the crucial role for schoolchildren of CPR training, its relevance in teaching adolescents^[13,55] and mandating legislation, the incidence of survival after OHCA does not appear to have significantly increased.^[56] About 90% of people who experience an OHCA die.^[57]

Among possible factors that could have limited the success of CPR training for schoolchildren, which is nevertheless recommended on a broad level,^[58] the possible age-based local legal limits in teaching and using the automatic external defibrillator (AED) in practice have been outlined, as well as the fact that schoolchildren commonly receive a standard instructor-led compression-only CPR course, whereas

using a real-time visual feedback device during CPR hands-on training significantly improves skill acquisition and retention.^[40]

Another negative factor could be the limitation on the part of children in chest compression depth, considered a fundamental feature for high-quality CPR and a factor affecting survival^[15-17]; compression depth correlates with physical characteristics such as increasing weight, BMI, and height.^[47]

Skill decay following CPR training could be another limit. Increasing evidence suggests poor retention of skills following CPR training, particularly affecting both the period and the components of the algorithm.^[59]

Finally, regarding barriers to deployment and pupil training in the use of AEDs in schools, some school leaders and teachers are concerned that AEDs are potentially dangerous, overly technical, and challenging to use and are ambiguous about whether schoolchildren are the right target group and which grade is suitable for defibrillator training.^[60]

The concept of CPR training for schoolchildren as a possible method of increasing bystander high-quality CPR rates needs to be implemented.

Are there other practical possibilities to increase CPR rates in cases of OHCA worldwide?

The role of universities and third mission activities

Universities are places of diffusion and extension of knowledge.^[61] The proper role of academic institutions is education, teaching applicable to real life, and the third mission, labeled as “a contribution to society”; indeed, the “Third Mission” is represented mainly by the social mission of universities and its contribution to communities and territories.^[62] In other words, “Third Mission Activities” could be considered an effort to educate citizens in general, to share knowledge, and distribute it as widely as possible by publicly articulated purposes.^[63]

In September 2019, the United Nations General Secretary launched “The Decade of Action,” a call for accelerating sustainable solutions to all the world’s biggest challenges, summarized in the Sustainable Development Goals (SDGs), including major public health concerns.^[64] This worldwide call for a decade of global, local, and people action was addressed to all sectors of society, including governments, local authorities, civil society, media, the private sector, unions, and academic institutions. The reciprocal roles of universities and the *Sustainable Development Goals* were outlined, especially those addressing a range of

social needs, including education, health, and social protection; from this point of view, universities are vital to progressing the SDG agenda, performing their unique function as enablers of change.^[65]

Undergraduate students as lifesavers: A global call to action

As stated above, OHCA continues to be a significant worldwide public health concern; therefore, more should be done to increase awareness and training in CPR. Several training initiatives could be used to improve this situation, and the challenge is to find the most efficient one, in detail, according to the actual setting.^[66] The ILCOR education guidelines guide citizens and healthcare professionals in teaching and learning the knowledge, skills, and attitudes to resuscitation to improve patient survival after cardiac arrest.^[67] Evidence-based instructional design is essential to enhance the training of lay providers and ultimately improve resuscitation performance and patient outcomes.^[66] Educating people with a comprehensive CPR educational program is an easy way to increase survival in this area. Still, it is impossible to reach the entire population with proper CPR training if these education programs are not mandatory.

An innovative and future-oriented solution has also proposed CPR training during academic courses. Young people are potentially necessary bystander CPR providers, and CPR training can be distributed widely as a mandatory part of the curriculum in all educational classes. Moreover, an independent association has been identified between having a higher education level and an increased likelihood of attending CPR training.^[68,69]

“Global call to action” teaching is necessary, in a mandatory manner: CPR training and retraining in undergraduate students, without any regard to course degree, type of university, country, or continent, with the final objective of transforming all undergraduate students as lifesavers in the occurrence of any OHCA is essential.

In this perspective, the possible development and implementation of international guidelines based on undergraduates’ specific skill attitudes and confidence using the following criteria have been suggested^[66]:

- 1) Development of a simple and basic evidence-based CPR training protocol for lay undergraduates;
- 2) Implementation of CPR protocols for students attending healthcare degree courses (higher implementation for undergraduates medical, nurse, and health degrees, also teaching the use of drugs and advanced procedures in the training of final-year undergraduates);
- 3) Evaluation of training protocols, their effects (positive, negative, and limits) considering university setting

and students' preferences, and in the case of introducing, if necessary, intermediate procedures revision;

- 4) Monitoring the effects of mandatory CPR training and retraining programs on undergraduate students' regional OHCA outcomes.

But there is also a secondary objective of this global call to teach and train CPR, in a mandatory manner, for undergraduate students.

Currently, too few certified instructors are available for CPR training in secondary schools to increase the number of potential CPR providers in the occurrence of OHCA.

In many cases where the number of instructors, time, space, and resources are limited, it is difficult to provide all schoolchildren and teachers with proper CPR training.

In a published research, no significant differences were found between the groups on overall Cardiff Test scores and the correctness of the CPR techniques during post-training and retention tests; all pupils showed sufficient CPR competence, even after eight weeks, coming to the conclusion that training by medical students or physical education student teachers is not inferior to activity by a registered nurse, suggesting that school teachers, student teachers, and medical students can be recruited for CPR training in secondary schools.^[70] Therefore, employing trained undergraduate students (especially medical and physical education students) as CPR instructors could be an appropriate solution to the shortage of CPR instructors in secondary schools. More trained lay rescuers can increase a person's chance of survival after OHCA.

Methods of teaching CPR to Undergraduate students

Methods of CPR teaching and training that engage undergraduate students ideally should also be captivating, with teachers/instructors able to hold the attention of the audience using compelling technologies: learning experiences that engage. Moreover, exciting learning CPR experiences engage undergraduate students that are "digital natives" with technology in their every pocket, and instructors should use methods employing the tools they understand.^[71]

Conventional cardiopulmonary resuscitation training

Classwork with in-person skill sessions represents the traditional education training for CPR. Live training, instead, has a considerable advantage due to real-time interaction between instructors and learners.^[72]

E-learning

E-learning today is the delivery, whether one-time training or a full degree, of learning material in a *synchronous* (everyone is online, usually via video and able to communicate at a set time) or *asynchronous* manner (the lecture is recorded, and assignments are submitted later).^[73] Live training has a considerable advantage due to real-time interaction between instructors and learners.^[72]

Until a few years ago, most online learning depended on the personal skills of teachers creating lessons and courses delivered via the internet.^[74] COVID-19 pandemic prevention policies, encouraging social distancing and discouraging direct contact, disrupted conventional modes of undergraduate student education and led to a dramatic acceleration in the diffusion of global e-learning, which today appears to be widespread.^[72,75]

In a randomized experimental study, across outcomes assessed after the course, e-learning training was not inferior to conventional classroom CPR training, concluding that it offers a practical, reasonably effective alternative to traditional CPR training, helping students achieve their educational goals.^[76] To provide CPR training to laypersons, e-learning can be a suitable alternative to conventional learning.^[72]

When used for medical education, the same technology offers an alternate, potentially timesaving, cost-utility, and cost-effective interface between students and instructors.^[77] However, research has also evidenced some limitations^[74]:

- certain technical limitations, such as unstable internet connection;
- the need to investigate the retention of knowledge and skills after regular intervals;
- the need for further studies on participants without prior CPR knowledge;
- since we are on the cusp of a new wave, studies aimed to evidence the achievement of educational goals in a population of students with specific characteristics or limitations should be encouraged.

Associations of the International Liaison Committee on Resuscitation (ILCOR) and other International Associations supporting CPR education are today offering, free or on payment, basic and advanced certified courses using e-learning platforms.

Recently, blended simulation learning experiences have been proposed, which combine e-learning online classwork with in-person skill sessions, as an alternative to conventional training in CPR or e-learning only.^[78]

Immersive interactive rooms

The immersive interactive classroom is an innovative educational facility, and a unique learning space, bringing multi-sensory environments into play and giving students an engaging and expansive learning experience. The main characteristics are:

- 1) *Fully interactive* - Allows students to step into a fully interactive immersive world that they can engage with through touch, sight, smell, and sound;
- 2) *Limitless content* - Possibility to simulate endless scenarios transporting students to environments that inspire them;
- 3) *Easy editing* - A fully integrated system allows you to create and edit content easily.

It can enhance realism and advance learning through a fully immersive medical training room. Immersive rooms allow students to train in many different environments.

Extended reality (XR)

Extended reality (XR) is an umbrella term for any technology that alters reality by adding digital elements to the physical or real-world environment to any extent; the word XR includes augmented reality (AR), mixed reality (MR), virtual reality (VR), and any new technologies that may be created in the future that alter reality, either by blending the digital and the physical world or by creating an entirely virtual environment.^[79]

In particular, VR offers a captivating way to learn in the classroom and beyond. CPR training in virtual worlds has been proposed for a decade;^[80] recent research has found that this type of simulation generates a stronger sense of empathy in users than regular video because of an effect known as embodied cognition.^[81] The VR methodology for CPR training positively impacts procedural knowledge, manual skills, and self-efficacy, with and without the physical mannequin. This supports the adoption of the proposed VR methodology to reduce instructor and mannequin time required to teach CPR to trainees.^[82]

When should CPR training be included in the undergraduate course curriculum?

Each university should create or integrate a mandatory CPR educational program for undergraduate students in the degree course curriculum. Like in the laypeople of First and Second Cycle Degree programs, CPR training for lay undergraduates should be started as soon as possible using evidence-based CPR training protocol: therefore, the aim should be to train all students within the first year of their course. This would be desirable, and, where possible, an end-course final examination could be taken with the issuing of a skill certification, with modalities depending on the characteristics of the CPR training undertaken.

As mentioned above, in the health degree courses, the mandatory CPR educational program should be implemented, improving rate and quality by using clear guidelines regarding the required proficiency level (International Liaison Committee on Resuscitation or decided upon by State and Territory curriculum authorities, having regard to local contexts).^[83,84] A higher implementation for undergraduates with medical, nurse, and health degrees should provide CPR retraining in the final year of the degree course, also teaching the use of emergency drugs and advanced procedures.

Where applicable, the CPR training courses for both laypeople or not could be enriched with additional sections focused on human factors and non-technical skills aimed at strengthening their self-confidence and willingness to help OHCA patients.^[85]

Conclusion

This brief report suggests a global call to action for CPR learning and training in the tertiary education system. It is addressed to all undergraduate students, without any regard to the degree course type, and aims to implement, not replace, the traditional school-centered CPR education training.

The proposal provides some distinctive elements of novelty, creativity, and innovation:

- 1) Since bystander CPR remains the principal factor in saving out-of-hospital cardiac arrest victims, and the prevalence of bystander CPR remains low, extending the CPR training course to the university educational system will significantly increase the number of people educated about life-saving maneuvers.
- 2) The enrolment of undergraduate students overtakes the age-related local legal limits in teaching and using the automatic external defibrillator and the limitation in chest compression depth by children since compression depth correlates with physical characteristics such as increasing weight, BMI, and height.^[47] Automatic external defibrillator and chest compression depth are considered the two most essential features for high-quality CPR and a factor affecting victim survival^[15-17];
- 3) The CPR training proposed during the academic courses is based on international guidelines, developed on undergraduates' specific skill attitudes, and implemented with evidence-based protocols.^[66]
- 4) Proposal includes innovative, captivating, and future-oriented CPR teaching and training methods that engage undergraduate students using compelling technologies (conventional training, e-learning, immersive interactive rooms, extended reality, etc.).
- 5) The secondary aim of this call to action is to recruit trained undergraduate students for CPR training in

secondary schools. The traditional school-centered CPR education training has, in many cases, a limited number of instructors, and it is difficult to provide all schoolchildren and teachers with proper CPR training. Employing trained undergraduate students as CPR instructors could be an appropriate solution to implement the shortage of CPR instructors in secondary schools.

Although the proposal of a global call to action for undergraduate students as lifesavers has several strengths and elements of novelty, some potential limitations must be highlighted.

Traditional CPR teaching and training include evaluations of practice skills performance, but giving and improving knowledge during training on CPR techniques is not enough: It is also important that the laypersons trained are willing to perform CPR as bystanders in the occurrence of a human life-threat event; an education session addressed to this aspect should be inserted as part of the educational program.^[86,87] CPR training is associated “per se” with increased willingness and confidence to perform CPR and use an AED.^[44,88]

The gender of the victim could be a further factor that influences the willingness of bystanders to perform CPR if an OHCA occurs. A recent study aimed to identify whether gender characteristics of OHCA victims are relevant to schoolchildren (who have been the key target group of CPR training worldwide in recent years) concluded that gender characteristics of OHCA victims, at least in schoolchildren, have a relevant impact on the willingness to perform CPR.^[89] It should be explored if a specific population of undergraduate students evidences preexisting gender-related inhibitions toward OHCA patients since this could limit the program’s success.

Costs for universities could be a barrier to giving massive CPR training to their undergraduate students. However, many low-cost methods provide basic life support (BLS) training beyond attending a traditional BLS instructor-led CPR class. Instructor-led distance learning may be a suitable alternative to conventional learning for delivering CPR training to laypersons.^[76] Also, hybrid-blended learning formats offer new opportunities to receive individualized CPR training in a flexible and convenient format.^[85] Finally, most universities are provided with simulation centers that could, without any cost, contribute to CPR training with their equipment and personnel.

In conclusion, extending the cardiopulmonary resuscitation training course to the university educational system could significantly increase the number of people educated in life-saving maneuvers. The final

objective is to improve the survival rate of patients with out-of-hospital primary cardiac arrest, which has dramatically increased worldwide.

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There are no conflicts of interest.

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