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Life-Saving-Experiments; Primary School CPR Skills Instruction Improves Teaching in Basic Science Knowledge Support

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ABSTRACT

Basic Life Support (BLS) improves survival in patients after cardiac arrest. Consequently, several worldwide efforts have been made to train all school children in cardiopulmonary resuscitation (CPR) skills. Until now, no methodology has been applied to the school science curriculum that facilitates the teaching of CPR at school.

The present study aims to implement an educational method of teaching human anatomy and physiology by teaching the theoretical and practical principles of CPR, BLS, and survival chain in primary school children. A controlled before-and-after study design with educative activities in science, including the cardiac, nervous, and respiratory systems, in order to assess their potential in early education in CPR. This methodology has been tested in primary school (n = 51), demonstrating that in the 9 - 11 age old group, they improved the learning of the basic science and learn the theory of CPR, BLS, and survival chain, and to apply the CPR maneuver correctly in terms of their frequency but not in terms of compression depth. In conclusion, CPR teaching methods combined applied in BLS as an educational teaching tool in basic and applied sciences.

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Introduction

Cardiac arrest is the leading cause of death in the world, with estimates of the incidence of emergency medical service (EMS) assessed out-of-hospital cardiac arrest (OHCA) in various continents ranging from 53 to 112 per 100,000 persons [1, 2]. It is one of the top three leading causes of death in industrialized nations [1]. To improve survival outcomes, it is critical to shorten the time between OHCA onset and the three associations in the chain of survival: early access to emergency medical services (EMS), initial cardiopulmonary resuscitation (CPR), and early defibrillation. Besides, multiple studies have demonstrated that layperson CPR increases the chance of survival by 2-3 fold [3-8].

Implementing new creative strategies to increase layperson CPR and defibrillation may improve resuscitation in priority populations. Furthermore, if this training takes place in schools, there is potential for a boosting effect and scope into priority communities with low bystander-CPR rates [9, 10].

The public health challenge is to develop educational programs that grant access to education in bystander CPR, defibrillation, and advanced care [3, 7]. These care must be delivered as quickly as possible, ideally within moments of the collapse of an OHCA. Achievement of such an aim requires the deployment of multiple properly directed educative programs within an EMS system; for this reason, new educational programs are needed that can be integrated with the current school education system [5, 11].

Consequently, the American Heart Association (AHA) and the World Health Organization, along with multiple other national and international groups, have endorsed CPR training in schools as a critical foundation to improve OHCA survival outcomes [3,4,5,8]. Therefore, it is essential to generate new educational strategies to achieve the diversity of students found in primary and secondary education in CPR training.

An educational strategy for CPR training should consider being integrated into the educational curriculum in science, being efficient in the use of time, with low-cost experimental activities, and with teaching aspects that allow students to discuss and empower themselves in a multidisciplinary way by considering ethics, health care, human physiology, and basic sciences [12].

Therefore, in this work, a series of experimental modules were designed and applied so that primary school students can understand profound aspects of anatomy and physiology, focusing on CPR. The proposed approach improves both the learning of scientific content and the addressing of the CPR training.

Methods

Procedure

Classroom intervention: A total of 6 sessions were developed over five weeks, with two evaluation sessions, three experimental sessions, and one training session on CPR, AED, and survival chain. During the first and the final session (week 5), students completed a written multiple-choice CPR and basic science knowledge quiz. Survey questions were validated by an expert, while the activities considered two volunteer teachers in 3 sessions of 90 minutes each. The experimental activities were carried out during the first three classes, and for the 4th session, two trained nurses (at least 20 hours of experience teaching Hands-Only CPR) taught and evaluated CPR. The students finished with a knowledge test, a replica of the pre-training test. Privacy was protected as the pre-and post-training surveys did not incorporate any personally identifiable information.

Subjects

We recruited schoolchildren from 9 to 11 years old from 6 different public schools in Santiago, Chile. To be eligible, inclusion criteria to test subject selection considered: signed consent of the parents, signed permission of the academic unit of each school, a health questionnaire to confirm continuing eligibility for the study, and that the subject has not taken any CPR course before.

CPR Training

Each child attended a practical session, with three different stations where the children taught CPR, AED management, and survival chain. Each training group was integrated by an instructor and 8-10 children. CPR station: Chest compressions were trained on a Little Anne training system (having four training manikins per class) with a feedback mechanism that clicks and software that measures chest compression depth. The guidelines involve giving 30 compressions at a rate of 100 per minute and chest depth of 4-6 cm, plus two ventilations with a volume of 500-600 ml each after the compressions [13]. AED station: The students taught how to operate an AED and practiced using a trainer-AED. Chain survival stations: consisted of instructor-facilitated hands-on instruction about the training program

Basic Sciences Session

Previously validated experimental activities of basic science were adapted and applied (detailed in the results section, Table 1). Each child attended three sessions of basic sciences: nervous system, cardiovascular system, and respiratory system, and those children who were absent from any of the sessions were excluded from the study.

Fantom CPR Quality Measure

CPR quality data were recorded for each subject using QCPR Instructor *Resusci Anne QCPR® plus Wireless* (Laerdal Medical) device while continuously connected to the Fantom. Collected data included the total number of compressions, the number of correct compressions (compressions delivered at the right rate and depth, with hands in the correct position and with full release of pressure), the number of compressions delivered to an accurate depth, compressions number ending without complete release of pressure on the chest, and duty cycle (duration of compression to total cycle time). To measure quality CPR, the selected method was only compressions (without ventilations).

Data Analysis

Analyses were performed with GraphPad Prism, including evaluating each variable for normality using Kolmogorov-Smirnov and Shapiro-Wilk normality tests. Descriptive statistics are presented as percentages. We used chi-square analysis to determine whether the differences in pre- vs. post-knowledge surveys were statistically significant.

Checklist of Body Position by CPR Quality Measure

To evaluate how the subjects maintain an optimal anatomical position while performing CPR, instructors performed a supervision at the last class using a guideline. The observed variables considered straight elbows (the arms should be extended and fixed, the shoulders should be vertically concerning the hands) [14].

Results

Training Program Description

The first three training sessions were oriented to basic experimental sciences, focusing on nervous, cardiovascular, and respiratory systems (Figure 1). The students successfully performed the scheduled experiments, and during each session of experiments, they received a class on basic concepts of physiology and human anatomy, which had relevance to CPR practice (Table 1). These sessions did not mention technical details but motivated the students by informing them that the last session would be simulation and CPR, highlighting the students to start their searches on the internet, reporting in each session knowledge that was not part of the program, and deepening each session in an autonomous way.

Figure 1: Representative Images of the Application of Experimental Activities
A) The scheme made by students of the Francisco Arriarán School on the steps to follow in the chain of survival during a training session.
B) Student performing chest compressions on the third day in Colegio Elvira Hurtado, Quinta Normal.
C) Training with an Automatic External Defibrillator (AED) on the thorax of a mannequin Little Anne Fantom.
D) Students in Quinta Normal performing structure-function association in their own " Brain Cap," which indicates anatomical regions selected by color and with functions titled in each one.
E) During the second session of lung activity, the students of the Francisco Arriarán School practiced fundamental concepts of respiratory physiology.
F) Model of the heart, which represents the flow of minor and significant circulation, pumped by a group of students from the José Alfonso School of the commune of Pedro Aguirre Cerda.

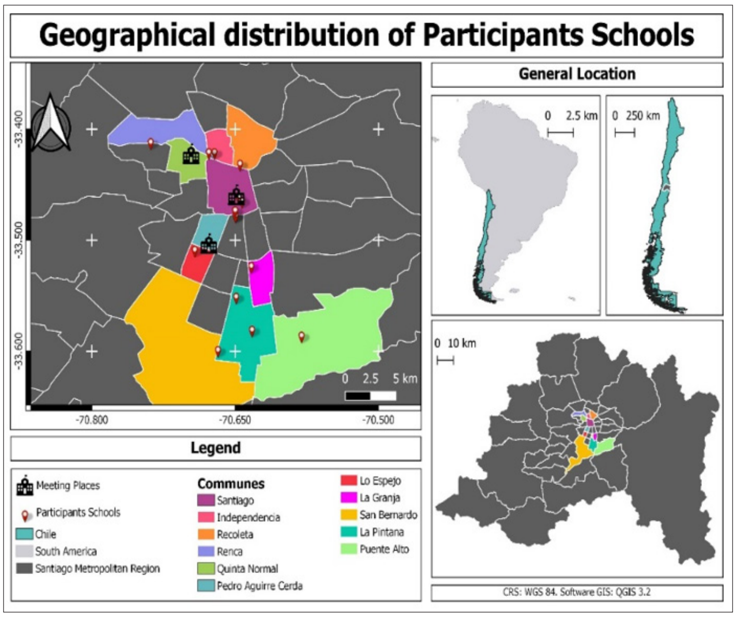
Table 1: Summary of Educational Content in Science, Contents of Other Educational Areas and Details of Experimental Activities of Each Session

Learning Goals	Learning Outcome: Basic-Science	Learning Outcome: Others STEAM Areas	Activities
- Anatomy of the heart - Cardiac physiology - Heart rate. - Central and peripheral pulses. - Protective elements of the heart	Explain the transport function of the circulatory system (food substances, oxygen, and carbon dioxide), identifying its basic structures (heart, blood vessels, and blood).	Apply and combine elements of visual language (including those from previous levels) in works of art and design with different expressive and creative purposes: color (complementary), forms (open and closed), light, and shadow.	- Homemade stethoscope with recycled materials - Artistic Manikin with significant and minor circulation -The heart cardboard model and hoses created a closed circuit where the liquid passed (blood).
- Lung anatomy -Respiratory mechanics. - Pulmonary Volumes -A gradient of CO2 and O2, -Negative pressure.	Explain the breathing model (inspiration-expiration-exchange of oxygen and carbon dioxide), identifying the basic structures of the respiratory system (nose, trachea, bronchi, alveoli, lungs).	Describe and apply mental calculation strategies: forward and backward counting; fold and divide by decomposition; using double the double to determine multiplications and their corresponding divisions	- Homemade spirometer with recyclable materials. - Lung model construction where students identify the structures and reply textures. - Respiratory math quiz, with the play “Alphabetical.”
- Anatomy of the nervous system. - Comparative neuroanatomy. - Structure-function relation with behavior. - Breathing and blood pressure regulation by the nervous system.	Identify structures of the nervous system and describe some of its functions, such as information management (spinal cord and nerves) and elaboration and control (brain).	Incorporate the new vocabulary extracted from heard or read texts in writing (Scientific literacy).	- Build a “Brain cap” folding paper. - Roleplay, where children guess brain damage region. - Kneading the 3D brain using flour, water, and dyes, and supported with text card

- Cardiorespiratory arrest - Delivering quality CPR. - Chain of survival. - Use and function of the AED. - OVACE - Conculsion	Determine the intensity of the physical effort manually, through the pulse, or using scales of perception of effort.	Participate in a guided way in the school community and the organization of the course: proposing and accepting initiatives, assuming responsibilities, establishing agreements through dialogue, and democratic decision-making.	- Mimic the stages of the survival chain. -Understand the use and function of the AED with an electrical heart model. - Simulation of a Teddy bear accident applies knowledge of anatomy associated with the CPR maneuver and activation chain of survival. - Roleplaying of convulsion, OVACE, and CPR with the Little Anne phantom.

Sample Description
72 students from different communes of the metropolitan region of Santiago Chile (demographic distribution of school to display in Supplementary Figure S1) participated in the classroom-based educational intervention in their respective schools from March to November of the year 2018 and took a training session to learn basic science and CPR. Of these students, all 72 completed the pre-training survey, 51 (71.8%) completed all sessions with the training program with the post-training survey, and 20 (28.2%) refused to test or had scheduling issues. Therefore, 51 students underwent an evaluation, were present on the day of experimental and practical testing, and finished all parts of the assessment. Tested students included those with special learning needs; most students were age-appropriate for their education level class (e.g., 10 years old in primary school).

Supplementary Figures



Supplementary Figure S1: Demographics Distribution of the Sample. Students' Location According to the School they belong to within the Metropolitan Region, from the SIP School Network

Regarding socioeconomic condition and aspects of the social level of the subjects, the 51 students represented a vulnerable portion of the population, both in their vulnerability indexes and ranked below the national average to Chilean metrics or indexes for vulnerability) [15]. Note that none of the students had prior knowledge or had attended first aid training before participating in this program. The mean time from the last class to the evaluation session was 28 days, fulfilling the planning for each school.

Basic Science Knowledge
At baseline, students performed a pre-test before applying for the training program and the retention re-evaluation. In the retention evaluation, the performance in the three areas was significantly higher compared to the baseline phase (Figure 2); because the surveys requested personally identifiable information, we analyzed survey results in paired analysis. Figure 2 relates the percentage of correct answers in the pre- and post-training survey. The percentage of correct answers increased from 56% pre-training to 72% post-training ($p < 0.0001$). Such a positive effect was not affected by gender. On the body mass index (BMI) class topics, subjects significantly improved basic sciences knowledge. However, an unexpected finding was that the education of the respiratory system was significantly higher compared to the other areas (Figure 2). This may be due to the fact that students of that age are reissuing basic concepts of the respiratory system. The most significant improvements were observed in CPR, AED, and survival chain, despite the considerable growth in anatomy and physiology. This fact is remarkable, showing that a single session combined with practical training substantially increases basic scientific understanding.

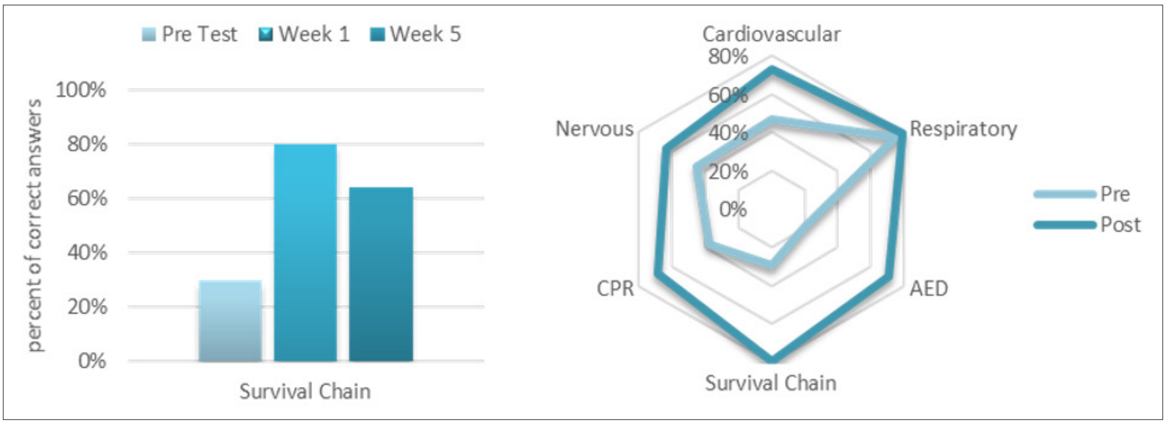


Figure 2: Primary Outcome Variables. Participants' Background Characteristics, The amount of CPR training, and Test Results. Pre- and Post-Training Survey Data Demonstrating a Statistically Significant Increase in Knowledge Acquisition of Cardiopulmonary Resuscitation (CPR) for Students Trained in High School.

BLS Knowledge and Skills

The right answers were increased for several significant concepts, including adequate compression rate, compression depth, appropriate circumstances to perform CPR, and ease of defibrillator use (Table 2). In a practical session, the students evaluated their performance in simulated assessed responsiveness and adherence to a checklist during the vital signs training test. Here, 93% of the subjects achieved the correct position during CPR, and 88% had the correct use of AED (Table 3). These students were also tested in CPR on an evaluation mannequin; 89% correctly performed the CPR techniques, providing 30 chest compressions. However, only 54% of all students provided the correct compression depth (Table 3).

Table 2: CPR Evaluation. Data Representing the Correct Pre- and Post-Training Survey Knowledge Acquisition of Cardiopulmonary Resuscitation (CPR), Survival Chain, and Automated Defibrillator (AED) Use.

Dimension	Before Training Program		After Training Program			
	N =51 Percent		N =51 Percent		P value	Example Question
It is better to do CPR	12	%	59	%	<0,0001	What is the first thing I should do when I arrive to help in an accident?
Check responsiveness	39	%	27	%	<0,0001	You are alone, and you meet a person who does not respond by speaking or touching and does not breathe. What is the first thing to do in this case?
Call for help	41	%	59	%	0,3763	When I call an ambulance to ask for help for an injured person, what important things should I report on the phone?
Call emergency	37	%	96	%	<0,0001	What number should be called to request an ambulance?
Right hands-only CPR technique	35	%	53	%	0,0489	What is the depth required for each compression in the chest of an adult person when performing the CPR technique?
Right compression frequency	29	%	65	%	<0,0001	What is the ideal number of compressions in the chest in one minute?
Criterion of use for an automated external defibrillator (AED)	10	%	53	%	<0,0001	Are you authorized to use an AED in case of cardiac arrest?
Correct electrode position of AED	18	%	43	%	0.0201	Could a person who is in cardiorespiratory arrest be injured when using an AED?
Performance of AED	24	%	65	%	<0,0001	What is the correct location of the patches of an AED?

Table 3: Students Tested for the Specific Skills Category as Listed, The % of Students Performing the Task Correctly Concerning Those Who Did Not. AED-Automatic External Defibrillators. SD Standard Deviation.

Percent of Success in Learning the Skills Taught	%	SD
Right compression depth	54%	0,33
Right compression frequency	89%	0,30
Starts immediately Right compression point	90%	0,15
Right elbows position	92%	0,27
knees separation	96%	0,19
Responsiveness (Speaks loudly and shakes shoulders, opens the airway and comes close)	100%	0
Right electrode position	91%	0,25
AED use	86%	0,23

Discussion

The idea of child-mediated health education is not original; however, its application to basic science remains novel and untested as an essential strategy to address significant disparities in outcome by the community [16-19]. The above is because schools provide large-scale, central settings accessed by people from all ranges of the social spectrum, among other apparent advantages of middle schools and students. Despite that, the lack of time to introduce new content to class is difficult. In this work, we have taken this opportunity to add a large part of essential science content complemented with knowledge of BLS.

While mainly driven by the understanding that the knowledge of CPR represents a core skill, the helpfulness of CPR training in schools has been questioned by some researchers due to students may not have the cognitive and physical aptitudes desirable to perform correctly such complex tasks [20, 21]. In our study, children aged 9-11 years have combined CPR learning with basic science aspects, achieving the correct hand position and the same compression rate. Although they generally could not compress the chest sufficiently, they discovered methods of performing chest compression that are similar to those used by adults. Teaching younger children provides knowledge for when they are adequately developed. Our student-led Basic Science-CPR model shows that using experimental and didactic instruction with low-cost kits and an efficient training intervention to deliver CPR and AED is enough for the educational intervention in low-income, minority neighborhoods. The proposed approach highlights the schools as meeting points for broad reach that encompasses all population segments, conferring a unique the opportunity to decrease disparities in accessing this kind of training.

Our future research will seek to determine long-term control trial knowledge retention of this educational intervention and measure associated trends in bystander CPR within reached communities.

This study had no control group in the skill of CPR or knowledge in basic science before our training program, similar to other studies [14]. The main idea is that the control group may have an intrinsic amount of basic CPR knowledge, but clearly, it is imprecise to use the dummy or the AED. We acknowledge that some basic knowledge might exist (such as calling an emergency number). However, the main idea remains that the cause of BLS training to the public is that there is an assumption that the information does not exist in the people.

Educational and health policies, as well as international scientific research show how essential it is to educationally intervene in school children complementing and adapting curricular contents taught in schools on the respiratory, circulatory and nervous systems, plus the intervention of health education carried out through an innovative didactic method [6,22-24]. All this in order that the general population understands the risk factors associated with cardiovascular events such as cardiac arrest, so that they not only know how to act, but also know one more technical terminology. However, they comprehend the underlying pathophysiology related to the anatomy, allowing them to handle the basic knowledge associated with CPR to apply it through a quality CPR maneuver. This type of early education can reduce morbidity and mortality in the out-of-hospital setting since immediate CPR increases the likelihood of survival.

Conclusion

Evidence shows that promoting and facilitating CPR and automated AED training through basic science experiments is thriving in a broad kind range of children. This paper applies successful experimental activities based on resuscitation skills trained at school, showing the improvement in the learning of basic sciences when combined with training in CPR, AED, and the chain of survival. Thus making the teaching of this specialized training compatible with the conventional school curriculum. This paper demonstrates that theory and resuscitation skills can be taught in a school for nine to eleven years old. The achieved outcomes allow redefining minimal training age and, more importantly, describing that teaching CPR skills improves the learning of complex basic sciences, incorporating a new argument for the recommendation that this skill can and should be learned in schools. Perhaps as educators, scientists, and health professionals, we must take a joint step in introducing the multidisciplinary learning of basic sciences applied to the public health of the community.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Authors' Contribution

JFT carried out the conception and design of the study, acquisition, analysis, and interpretation of data, drafting of the manuscript, and critical revision of the paper for proper intellectual and material support, such as research supervision. JFT, CB, WS, and NL contributed to the acquisition of data and critical review of the manuscript for valuable intellectual content. FS participated in the conception and plan of the study, analysis, and interpretation of data and carried out a critical revision of the paper and material support. All authors read and approved the complete document.

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Highlights

CPR teaching at school improves essential science learning in anatomy and physiology.

Just 3 experimental basic science lessons are enough to improve CPR learning.

Primary students can successfully learn CPR and BLS skills.

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We want to thank the staff and students at Red de Colegios SIP, for allowing us to deliver CPR and AED training to their school. A special thanks to the MicroMundo Project, who make our community education programs possible. Sources of funding: Biomedical Neuroscience Institute, Universidad de Chile, Universidad Diego Portales. We are financially supported by ANID FONDECYT Postdoctorado 3220094, Anid doctorado 21192214, FONDEF Idea ID21I10289.

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