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REVIEW TOPIC OF THE WEEK

State Requirements for Automated External Defibrillators in American Schools

Framing the Debate About Legislative Action

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ABSTRACT

Installation of automated external defibrillators (AEDs) in schools has been associated with increased survival after sudden cardiac arrest. An authoritative academic research database was interrogated to identify all current state statutes pertaining to AEDs in schools. As of February 2016, 17 of 50 U.S. states (34%) require AED installation in at least some of their schools; the remaining states have no legislation. However, requirements are far from comprehensive in these 17 states. Only 5 states offer unequivocal funding to schools for purchasing AEDs. A minority of U.S. states have legislation requiring AED placement in schools, and even fewer provide funding. State legislatures that have not yet enacted legislation requiring AEDs in schools may look to neighboring states for examples of child and adult lifesaving law. Placement of an AED in schools should be implemented with an emergency response plan that trains staff in the recognition and response to cardiac arrest. (J Am Coll Cardiol 2017;69:1735–43)

Sudden cardiac arrest (SCA) is the leading cause of death in the United States, including in school- and college-aged individuals. The Resuscitation Outcomes Consortium found an incidence of 3.7 of 100,000 patient-years and 6.3 of 100,000 patient-years for children and adolescents, respectively (1). Others found an incidence of SCA in school-age children of 2.1 of 100,000 per year (2). These deaths, although infrequent, are particularly tragic because, except for their propensity for lethal arrhythmia, most individuals have an otherwise excellent life expectancy.

When the SCA involves a shockable rhythm, the most important determinant of survival is time from collapse to defibrillation. Survival is estimated to decrease 10% every minute until a shock is applied (3). Therefore, the American Heart Association (AHA) currently recommends placement of automated external defibrillators (AEDs) in selected locations with a high population density, such as airplanes, airports, shopping malls, and large apartment complexes (3). Several studies have reported more favorable SCA outcomes using this strategy (4–8), including a randomized trial (5).

In observational, largely uncontrolled studies with small numbers of SCA cases, installation of AEDs in schools and colleges has also been associated with increased hospital survival (9–12). The Resuscitation Outcomes Consortium found that in children, the survival rate of SCA was 6.7% to 10.2% (1). In contrast, the survival rates of students in schools with AED programs who had shockable rhythms

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ABBREVIATIONS AND ACRONYMS

AED = automated external defibrillator

CPR = cardiopulmonary resuscitation

EMS = emergency medical services

SCA = sudden cardiac arrest

VF = ventricular fibrillation

ranged from 64% to 72% (9,11). At least in part, such higher survival may have resulted from SCAs in schools being witnessed, leading to earlier cardiopulmonary resuscitation (CPR), and earlier arrival of emergency medical services (EMS).

Requirements for school AEDs in the United States vary widely across states. Public health issues are often legislated and administered at the state level, and this has led to a wide diversity in requirements. We reviewed a comprehensive database of pertinent current state statutes and reviewed the data in published reports supporting efficacy of AEDs in schools and the questions that remain about their installation.

LEGISLATIVE SEARCH METHODS

LexisNexis Academic (Dayton, Ohio), an academic research database, was used to find current state statutes and regulations. LexisNexis contains the as-published statutory codes from all states, which include all laws of a general and permanent nature, as enacted by the respective states legislatures. In addition, LexisNexis publishes administrative codes that contain rules that have been adopted by the state agencies to implement, interpret, or make specific the law enforced or administered by the agency. To comprehensively tabulate all extant legislation, the terms "external defibrillator," "AED," "defibrillator," and the global character "defib!" were searched under statutory code, administrative code, and constitution in February 2016. All laws pertaining to AEDs in schools, state buildings, health clubs and facilities, and other miscellaneous public access locations were included in our tabulation. Laws pertaining to the requirement of AEDs in nursing homes or senior facilities, and "Good Samaritan" laws were also tabulated. Legislation passed by only 1 house of a state legislature might be listed in other searchable databases, but these bills might never have achieved the status of law, and were not included in our tabulation.

School laws were assigned subjective scores of 1 to 4, depending on their requirements, as follows: 1 = requires AEDs in both public and private schools; 2 = requires AEDs in public schools; 3 = recommends AEDs in schools; and 4 = no legislation pertaining to schools. A similar methodology was followed for the classification of state buildings. In addition, we also tabulated legislation concerning health clubs, gambling facilities, and other nonhealth facilities. The aforementioned were assigned scores from 1 to 3, depending on their requirements, as follows: 1 = requires AEDs; 2 = recommends AEDs; and 3 = none. Once the laws were tabulated, a risk metric was assessed by adding the sum of the 3 categories.

Individual state laws that required AEDs in schools were further categorized in detail by the types of schools they covered, as follows: public schools; private schools; and/or colleges. State laws that required any schools to have an AED on site were investigated for specific language pertaining to funding. These states were then divided into the following 4 categories: 1 = unequivocal additional state funding; 2 = funding contingent on periodic legislative appropriations; 3 = local Board of Education funding; and 4 = unfunded mandate.

We cross analyzed the number of states that required AEDs in state buildings with those that did not require AEDs in schools, as well as those that required AEDs in health clubs and other facilities, but did not require them in schools.

The number of elementary and secondary schools per state and the number of students per state were accessed from published 2011 statistics in which the most complete state statistics are available (13) (see Online Appendix 1 for specific web page addresses). From state laws and published statistics, we estimated the number of schools and the number of students attending them in states without AED requirements.

RESULTS OF LEGISLATIVE SEARCH

Table 1 shows U.S. state legislation concerning AEDs in schools as of February 2016. State-by-state summaries of all laws pertaining to public access AEDs are shown in Online Table 1 and the original text of all public access defibrillation legislation may be found in Online Appendix 2. Seventeen states (34%) had some legislation that required AED installation in schools (**Central Illustration**). The remaining 33 states had no legislation that required AED installation in schools. Of the 17 states that required AEDs, 1 comprehensively requires them in public grade schools, private schools, and in colleges; 4 require them in public grade schools and colleges; 2 require them in public and private grade schools; 9 require them only in public grade schools; and 1 requires them only in colleges. Three of the 17 states specify that AEDs are only required in schools that participate in interscholastic athletic programs. In these 3 states, interscholastic athletic participation accounted for only 17% to 28% of public schools.

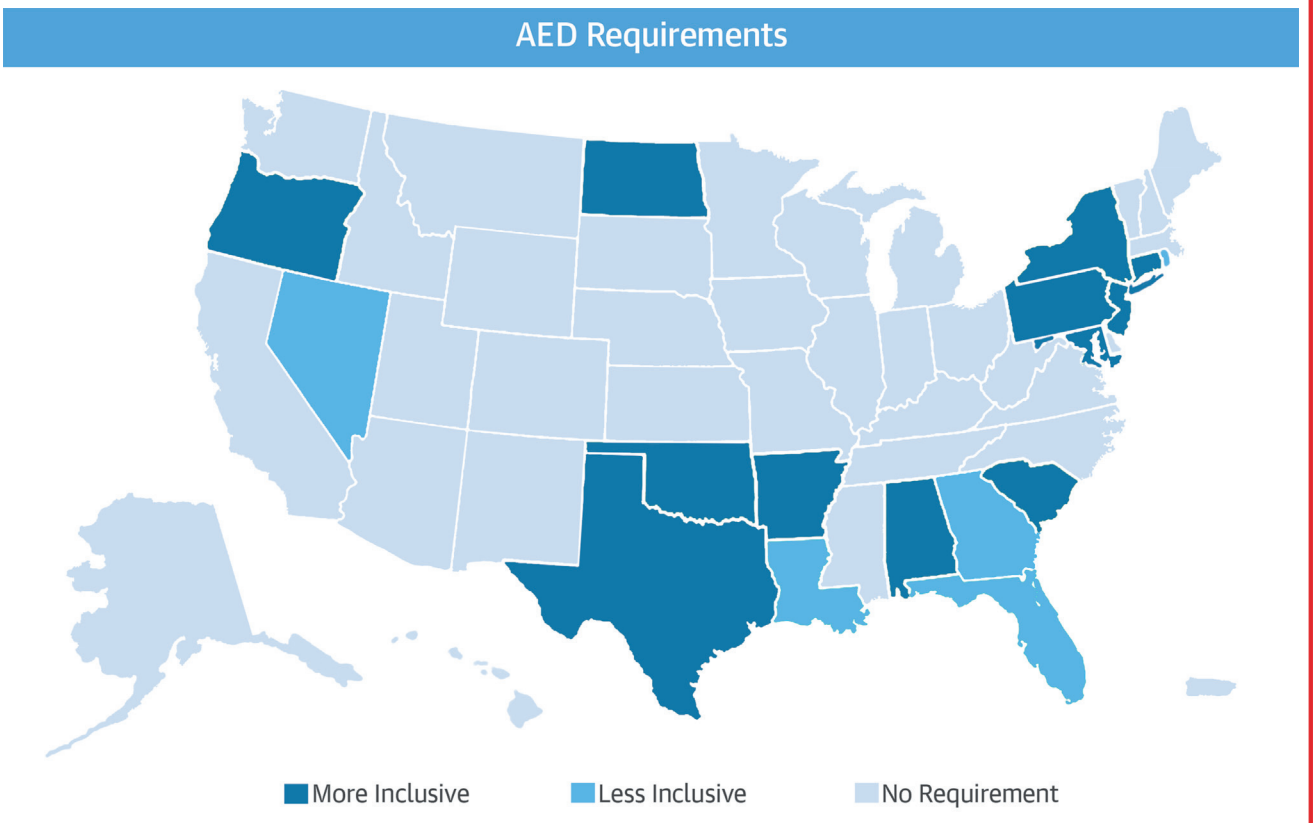
From published statistics, we calculated that 25% of U.S. schools are in states that require installation of AEDs in any school; they are required by state law in 29% of U.S. public schools and 13% of private

TABLE 1 U.S. State Legislation Concerning Public Access AEDs

State	Schools: 1 = Required in public and private 2 = Required in public 3 = Recommended 4 = No legislation	1 = Unequivocal state funding 2 = Contingent state funding 3 = Local Board of Education funding 4 = Unfunded	State Buildings: 1 = Required 2 = Recommended 3 = No legislation	Sports Club, Gambling and Nonhealth Facilities: 1 = Required 2 = Recommended 3 = No legislation	Risk Metric	Nursing Home Required
AK	4	–	3	3	10	–
AL*	2	1	3	3	8	–
AR*	2†	2	1	1	4	–
AZ	4	–	1	3	8	–
CA	3	–	1	1	5	–
CO	3	–	3	3	9	–
CT*	2†	4	3	3	8	–
DE	4	–	3	3	10	Yes
FL‡	2§	4	2	3	7	Yes
GA‡	2§	2	3	3	8	–
HI	4	–	3	3	10	–
IA	4	–	3	1	8	–
ID	4	–	3	3	10	–
IL	4	–	3	1	8	–
IN	4	–	3	1	8	–
KS	4	–	2	3	9	–
KY	4	–	3	3	10	–
LA‡	2§	4	3	1	6	–
MA	4	–	3	1	8	Yes
MD*	2	3	3	1	6	–
ME	4	–	3	3	10	–
MI	4	–	3	1	8	–
MN	4	–	3	3	10	–
MO	4	–	3	3	10	–
MS	4	–	3	1	8	–
MT	4	–	3	3	10	–
NC	4	–	1	2	7	–
ND*	2	1	3	3	8	–
NE	4	–	3	3	10	–
NH	4	–	3	3	10	–
NJ*	1	3	2	1	4	Yes
NM	4	–	3	3	10	–
NV‡	2‖	3	1	2	5	–
NY*	2	3	1	1	4	–
OH	3	–	3	3	9	–
OK*	2†	4	3	3	8	–
OR*	1	1	1	1	3	–
PA*	1	2	3	1	5	–
RI‡	2¶	1	1	1	4	–
SC*	2	2	3	3	8	–
SD	4	–	3	3	10	–
TN	3	–	3	3	9	–
TX*	2	1	3	3	8	Yes
UT	4	–	3	3	10	–
VA	4	–	3	3	10	–
VT	4	–	3	3	10	–
WA	3	–	3	3	9	–
WI	4	–	3	3	10	–
WV	4	–	3	3	10	–
WY	4	–	3	3	10	–
DC	4	–	3	1	8	–

*More inclusive legislation; these states at least require automatic external defibrillators (AEDs) throughout a specified grade range (e.g., all high schools). †Required in schools only if funding is available. ‡Less inclusive legislation; they require AEDs either in schools in specified interscholastic athletics or in counties exceeding specified population limits. §Required in schools with interscholastic athletic programs, 17% to 28% of the schools in these states. ‖Required only in counties with populations >100,000 (2 of 16 counties in the state). ¶Required only in state colleges.

CENTRAL ILLUSTRATION **School AED Legislation by U.S. State**



Sherrid, M.V. et al. J Am Coll Cardiol. 2017;69(13):1735–43.

U.S. States with any legislation concerning automatic external defibrillators (AEDs) in schools are coded in **medium or dark blue**. Those with more inclusive statutes are coded in **dark blue**; they require AEDs throughout a specified grade range (e.g., all high schools). Those with less inclusive statutes are coded in **medium blue**. They require AEDs either in schools in specified interscholastic athletics or in counties exceeding specified population limits. Those states without any legislation concerning AEDs in schools are coded in **light blue**.

schools (Online Table 2). Nearly 35 million public elementary and secondary students attend school in U.S. states where there is no legislative requirement for a school AED.

Of the 17 states that have any school AED requirement, 5 states reimburse or pay for the AEDs. Four states provide for funding contingent on periodic appropriation by the legislature. Four states require the local Board of Education to provide AEDs. In the remaining 4 states that require AEDs, the mandate is unfunded.

Conversely, several states have laws that require AEDs in other facilities and buildings, but not in schools. Three states require AEDs in other state office buildings; 8 states require them in health clubs; 1 requires them at racetracks, gambling structures, and on excursion gambling boats; 1 requires them in licensed gaming establishments; 1 requires them at horse tracks, and sheriff and police departments; and 1 state requires them in jails. Despite the diversity of this legislation, none of these 15 states also require AEDs in schools. Nineteen states had a risk score of 10, indicating that they do not require AEDs anywhere in their jurisdiction. All states had Good Samaritan laws, protecting bystanders who use AEDs in resuscitation efforts from liability.

DISCUSSION

Seventeen of 50 U.S. States now require AED installation in at least some of the schools in their jurisdictions. This represents a modest increase from the 9 jurisdictions that required any AED installation in 2010 (14). However, requirements in individual states

are far from comprehensive. For example, only 1 state requires AEDs in both private and public schools, as well as in colleges. Another 4 states require AEDs in public schools and colleges, but not in private grade schools. The remaining 12 states that have any school AED requirements have less comprehensive legislation. Moreover, only 5 states offer unequivocal methods for funding or reimbursement to schools and school districts for the purchase of AEDs. The remaining 12 states require AEDs in schools, but only have funding contingent on periodic appropriation, local Board of Education funding, or as an unfunded mandate.

AEDs IN SCHOOLS. AEDs are designed to be easy to use, and provide voice instructions and visual cues to guide the user through all the appropriate steps. Extant school AED programs have included training for adult responders. However, in a simulator study, even students with no previous AED training could quickly, accurately, and effectively place pads and follow AED prompts, including standing clear during shock delivery (15-17).

A questionnaire study of SCA in U.S. high schools showed that survival of student athletes with witnessed arrests was high in schools where AEDs were available, with nearly two-thirds surviving to hospital discharge (9). In all, 1,710 high schools with an on-site AED program were surveyed. SCA cases were reported by 36 of 1,710 schools (2.1%), including 14 high school athletes and 22 older nonstudent SCA cases. Twenty-three cases (64%) survived to hospital discharge. The investigators concluded that 2 in 50 U.S. high schools can expect a SCA event each year. This is consistent with previous studies in which the annual probability of SCA occurring in high schools ranged from 0.8% to 2.1% (18,19).

Mitani et al. (10) reported the temporal association of favorable neurological outcomes of SCA in 7 to 15 year olds in Japan from 2005 to 2009 as the number of public access AEDs increased, after AEDs were approved for citizen use in 2004. In Japan, the number of public access AEDs increased from 9,906 to 203,924 during that period, and 29% of AEDs were situated in schools. Among 128 children with ventricular fibrillation (VF)-SCA during these years, 29 (23%) received a first shock by a bystander. In these 29 cases, 16 (55%) had a favorable neurological outcome. Over the 5 years tracked, the proportion of patients initially shocked by a bystander (as opposed to EMS) increased from 2% to 21% ($p = 0.002$ for trend), and the proportion with favorable neurological outcomes increased from 12% to 36% ($p = 0.006$), particularly for those resuscitated in public locations. Collapse to defibrillation time was shorter when administered by bystanders than by EMS (3.3 min vs. 12.9 min), and this time was independently associated with favorable neurological recovery. In Japan, by 2009, AEDs had been installed in 72% and 89% of elementary and middle schools, respectively. This study, although prospective and nationwide, was limited by few patients because many patients with VF arrests did not have bystander defibrillation, and by a weak temporal control comparison. Training in CPR could have increased during the period to explain improved outcomes. Also, the investigators could not distinguish whether the SCA had occurred in schools because of the limited data acquired.

Mitani et al. (11) reported a second complementary, nationwide, retrospective survey study of 58 cases of children with out-of-hospital SCA who received prehospital resuscitation in the same years, and where the location of arrest was determined; 55% occurred at school. Children who had a SCA at school, compared with out of school, were more likely to have had bystander defibrillation (38% vs. 8%; $p = 0.01$) and more favorable neurological outcomes (69% vs. 35%; $p = 0.02$). The results were consistent with the concomitant population-based study. This study was limited by its retrospective survey design, in which the primary response rate from receiving hospitals was 57%. Also, witnessed SCA in schools might have prompted more rapid CPR, which would explain the favorable neurological outcomes.

Intersocietal task forces have recommended that all schools have emergency action plans for SCA because the most important factor for successful survival after SCA is a trained responder who can start CPR and provide early defibrillation (20,21). The 2004 intersocietal paper, including the AHA, recommended AED installation for all schools where EMS arrival would be unlikely within 5 min after the arrest (20). AEDs were also recommended if a SCA might be expected in the next 5 years, or if there were children attending the school with heart conditions that might predispose them to SCA. Furthermore, a 2011 AHA and intersocietal document recommended that student training in CPR and AED use should be a requirement for graduation from secondary school, and that state legislation should unequivocally support and enforce this requirement (22). However, the document stopped short of recommending AED purchase for schools or recommending legislation in this regard. Moreover, the AHA currently makes no specific recommendations regarding universal AED placement in schools, despite estimations

that 63.6 million individuals, 20% of the combined U.S. child and adult population, may be found in schools on any given school day (20,23).

Placement of AEDs alone are unlikely to improve outcomes; they should be placed with a plan for implementation in which all staff are trained in the use of the AED, integrated with their CPR training (22–26). The practical aspects of introducing an AED program in schools as part of comprehensive emergency response planning was recently reviewed in the National Association of School Nurses journal (23). This thoughtful review discusses the previous recommendations (20) for medical oversight, appropriate training, coordination with EMS, AED maintenance, and an ongoing quality improvement program to monitor training. The emergency plan, including plans related to the AED, should be widely distributed to the faculty and staff, with staff participation in drills (modeling those already in existence for fire or lockdown), and annual review of the program and post-incident discussion. A successful cardiac emergency response drill is defined as a successful completion of the full drill in ≤5 min.

SCA IN STUDENT ATHLETES. Vigorous exercise is a known trigger of SCA (27,28), and much research and debate regarding SCA in young people has focused around exercise-induced SCA in athletes. Because young athletes appear to be at the pinnacle of physical conditioning, their sudden demise appears paradoxical and appalling. The incidence of SCA in young athletes has been reported at 2.3 to 4.4 of 100,000 per year (29,30), with a wide variability, depending on the population evaluated and the study methodology (29–31). SCA on the playing field underscores the need for prevention and careful screening by established recommendations.

However, although SCA in young competitive athletes is an important issue, it may detract from the larger benefit of legislating expanded public access defibrillation to schools in general. SCA occurs more often in school-aged nonathletes than in athletes (2). For example, from 2000 to 2014 in Hennepin County, Minnesota, SCAs in the young (ranging from 14 to 23 years of age) were 8-fold more common in nonathletes than in athletes, and 3-fold more frequent, in terms of incidence (2). Because of the higher incidence of SCAs in school-aged nonathletes compared with athletes, it is not clear how one can justify state AED requirements limited only to the athletic field. Three U.S. states currently specify that AEDs are only required in schools that participate in interscholastic athletic programs, which are only 17% to 28% of public schools in these states, leaving the remaining schools with no legislative requirement for AED installation. Although the effort to prevent playing field death is laudable, a parallel extension of AEDs into the general academic environment would seem an appropriate response to new observations.

Furthermore, although most of the attention during sporting events is focused on the athletic field, most SCA cases during sports occur among the spectators. This is not simply a matter of spectator volume. Watching sports is associated with an increased risk of SCA, which has been attributed to the excitement accompanying this activity (32). Two large studies of SCA in sports arenas estimated the incidence of SCA as 1 in 589,000, and 1 in 267,000 spectators, respectively (33,34). Thus, the placement of AEDs at school sporting venues will also benefit the audience and coaching staff. More adults than children may be resuscitated by AEDs in schools and their environs (19).

An Australian study, in which lay rescuers were trained and equipped with AEDs at major sporting events, demonstrated an on-site survival among patients with VF of 86%, with a subsequent 71% survival to hospital discharge (35). Survival in 9 of 14 (64%) U.S. high school athletes was reported when an AED was applied an average of 3.5 min after collapse (9). Defibrillation is not successful in all circumstances (36,37). However, failure of the AED in isolated cases should not detract from its established benefit in other athletes, the rest of the student body, teachers, bystanders, coaches, and spectators.

OBSTACLES TO AED IMPLEMENTATION IN SCHOOLS. The principal obstacle of installing AEDs in schools is cost (18,38). In states with large numbers of schools, the cumulative cost of requiring an AED can become substantial. For example, California has >10,000 public schools and >4,000 private schools. However, 2010 yearly overall expenditures per student averaged $11,193 at U.S. elementary schools and $12,464 at U.S. high schools. Spending per student was the highest in the world (39). In comparison, AED purchase costs range from $1,250 to $1,500, and costs $250/year for maintenance, with an expected useful life of 8 to 10 years (40). Initial training of local personnel is estimated at $300. Therefore, the $3,300 cost of 2 AEDs and training per school would be small compared with the overall cost of $11,000 to $12,000 per student (20). Schools could assure that responders are present at highly attended school sporting events. Importantly, local EMS could provide emergency planning consultation at no charge in many communities, and practical AED training could be added to the existing CPR curriculum.

A comprehensive approach to costs and benefits of AEDs should include the acquisition and maintenance costs of an AED, costs of training responders in CPR and AED use, as well as downstream health care costs. In a 10-year model of AED effectiveness at National Collegiate Athletic Association Division I universities, the cost per life immediately resuscitated was $52,400, and the estimated cost per life-year gained ranged from $10,500 to $22,500 (12). The incremental cost-effectiveness of the program is influenced by the frequency of use of the device. The latter depends, in part, on the size of the student body in the school.

Population-based treatment programs usually require an up-front cost, which can threaten the short-term need for budget neutrality. Installing AEDs in schools would be no different (20). However, successful AED treatment reduces long-term downstream costs, both direct and indirect, in terms of productivity (41). For example, the lifetime health care costs of a single student who experiences severe cognitive and physical incapacity following a SCA are enormous, and would likely pay for the initial purchase price of most states' total AEDs.

We note that many states, with no requirements for school AEDs, place a higher legislative priority for required AEDs in other locations, such as state office buildings, health clubs, gambling facilities, racetracks, and jails. Timely AED availability is important in all population-dense settings, and an AED requirement in schools should be added in these states as part of a policy to expand the reach of public access defibrillation community wide.

Liability concerns are sometimes cited as an obstacle to AED installment. However, after passage of the federal Cardiac Arrest Survival Act (Public Law 106-505), all U.S. states have laws providing Good Samaritan protection for lay AED responders. Therefore, liability concerns should not present an obstacle to introducing AEDs in schools. In other settings, such as sports stadiums and other public venues, AEDs are often installed because of liability concerns over not having a device available (42,43).

REMAINING QUESTIONS

A remaining issue is whether favorable survival for SCA in schools might be the result of witnessed arrests in the school environment, consequent early CPR initiation, and early calls to EMS. Also, due to the observational nature of the published school studies, one cannot infer a causal association between use of an AED and survival. Although not performed specifically in schools, the PAD (Public-Access Defibrillation and Survival after Out-of-hospital Cardiac Arrest) trial, sponsored and monitored by the National Heart, Lung, and Blood Institute, offered insight into these issues (5). More than 19,000 volunteer bystander responders were randomized to emergency action plans that included either CPR or CPR plus bystander AED administration. All volunteers received CPR training; thus, both groups included active interventions. This design tested a strategy of supervised public AED implementation under the condition of an optimally trained layperson-enacted response plan. There were more survivors to hospital discharge with volunteers trained in CPR plus AEDs (30 survivors of 128 arrests) than there were with volunteers trained only in CPR (15 of 107; $p = 0.03$; relative risk: 2.0; 95% confidence interval: 1.07 to 3.77).

Survivors in both groups occurred almost exclusively in those resuscitated in public locations; survival was rare in both groups in residences. Thus, the positive results from the AEDs in this study were almost entirely driven by the SCAs that occurred in public and were witnessed. Witnessed SCAs, such as those that occur in schools, are those that are most likely to attract rapid CPR. The PAD study showed an incremental survival benefit of AED deployment in witnessed SCAs above and beyond that conveyed by rapid CPR alone.

It is unlikely that such a randomized trial of AED and CPR training versus CPR training alone will be performed in schools. The reported studies of AED usefulness in schools have included relatively few SCA patients because SCAs are uncommon. More comprehensive surveillance studies to assess outcomes of SCA in schools with AEDs are indicated. We are not aware of any current data concerning the proportion of U.S. schools that have already installed AEDs.

STUDY LIMITATIONS

We used a comprehensive database to identify current state laws pertaining to AEDs up until February 2016. We recognize that state statutes represent a moving target, and statutes may have changed in some states by the time of publication of this paper. However, some legislation promoted by committee, or passed by 1 house of a state legislature (and listed in error in other databases as law) may never actually be enacted into statute. It is not clear that state legislation would invariably result in AED installation, highlighting the need for adequate regulatory authority (44).

CONCLUSIONS

This review can inform the debate about expanding community access defibrillation into schools, both

the rationale and the remaining questions posed by such a strategy. Only a minority of U.S. states have legislation requiring AED placement in schools. All such decisions are judgments that involve expense, prioritizing the allocation of resources, and system-wide effort. However, adding an AED to educational budgets would be a small line item, because of the high total expenditure for education per student in the United States. Interdisciplinary committees, and their constituent organizations, by providing previously acquired data about public access and school AEDs, and expected outcomes, may promote an informed debate. State legislatures that have not yet enacted such legislation may look to neighboring states for examples of child and adult lifesaving law.

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KEY WORDS athletes, cardiopulmonary resuscitation, sudden cardiac arrest, ventricular fibrillation

APPENDIX For the URLs of published U.S. school statistics and the original text of public access defibrillation legislation by state as well as supplemental tables, please see the online version of this article.