Automated external defibrillators in schools?

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Objective: Automated external defibrillators (AEDs) placed in public locations can save lives of cardiac arrest victims. In this paper, we try to estimate the cost-effectiveness of AED placement in Belgian schools. This would allow school policy makers to make an evidence-based decision about an on-site AED project.

Methods and results: We developed a simple mathematical model containing literature data on the incidence of cardiac arrest with a shockable rhythm, the feasibility and effectiveness of defibrillation by on-site AEDs and the survival benefit. This was coupled to a rough estimation of the minimal costs to initiate an AED project.

According to the model described above, AED projects in all Belgian schools may save 5 patients annually. A rough estimate of the minimal costs to initiate an AED project is 660 EUR per year. As there are about 6000 schools in Belgium, an national AED project in all schools would imply an annual cost of about 3960000 EUR, resulting in 5 saved lives.

Conclusions: As our literature survey shows that AED use in schools is feasible and effective, the placement of these devices in all Belgian schools is undoubtedly to be considered. The major counter-arguments are the very low incidence and the high costs to set up a school-based AED program. This review may fuel the discussion about whether or not school-based AED projects represent good value for money and should be preferred above other health care interventions.

Keywords: Cardiac arrest – resuscitation – automated external defibrillator – paediatrics – schools.
Incidence of cardiac arrest with a shockable rhythm in schools

In a registry from Seattle/King County (USA) between 1990 and 2009, Lofti et al. found 141 non-traumatic cardiac arrests in schools. Among these, 71 were among students (52 between 12 and 18 years, 12 between 3 and 11 years) and 70 among faculty and staff (31 between 12 and 18 years, 15 between 3 and 11 years, and four university college students). An additional 10 arrests occurred among faculty and staff, 65 among adults not employed by the school and 7 among adults with independent school association. The overall incidence of cardiac arrest in students was 0.05 per 100 000 per year (with no significant differences between age subgroups). The overall incidence of cardiac arrest among faculty and staff was 0.11 per 100 000 per year (i.e. about 2.19-fold greater compared with students). For the large group of unaffiliated persons, school-based incidence could not be estimated. The first registered rhythm was ventricular fibrillation (VF) or ventricular tachycardia (VT) in 99% (97%). In all, 11 of the 22 cases in students occurred in the setting of physical activity. In Osaka (Japan), 34 non-traumatic cardiac arrests were 10 cases among students, the incidence (1 per 100 000 per year) was 0.3 among elementary schools, 0.54 for junior high schools, 0.64 for high schools and 1.32 for universities. Among school faculty and staff there were only 3 cases, i.e. an incidence of 0.31 per 100 000 per year. For the 17 collapsed victims the first registered rhythm was VF or VT in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28). In 15 cases, rhythm was VF or VT; in 7 cases, rhythm was tachycardia (VT) in 76% (21/28).
- the development of a team for monitoring and maintaining the AEDs.

Several authors report on studies related to school-based AED programmes. Typically, the studies showed that AEDs are used by people in schools in Belgium12,14,19. Regarding its effectiveness, we found no studies thoroughly assessing a school-based AED programme. Therefore, it is not scientifically proven whether (and why) an on-site AED was not used in a cardiac arrest case, how often (and why) unsupervised victims occurred before check defibrillation, and how often AED use in patients with a non-shockable rhythm had deleterious effects. Only case studies, surveys, and observational studies were collected via structural telephone interviews of school staff. Of the 19 cases with an AED present at the school, 6 device was used in 3 cases. In those cases no explanation was reported, detailed recognition of cardiac arrest due to cardiac activity – as opposed to sudden cardiac death – and collapse after the school day with bystanders being present in the nearby presence of an AED. No indicators for in-school use were found, as the bystanders were not trained to use the AED. On-site AED use was applied to at least 50% in the National Registry for AED use in Sports, and in at least 20% in the CARES registry. For both registries, we found that the survival rate among students and non-students (9/14 and 14/22, respectively) was higher in schools equipped with AEDs (80% (9/11) in comparison with 40% (5/12) in schools without AED use12). This regards to the importance of early bystander CPR and early defibrillation in a VVT/VT case, as some rules of thumb may be used: (1) survival rate may be as high as 85% if defibrillation is performed within 5 minutes of the collapse; (2) for every minute delay in defibrillation the survival rate decreases by 10-12% in the absence of bystander CPR; (3) the survival rate decreases by 75-85% with the absence of bystander CPR and delay of 4-5 minutes until on-site AED use is performed; (4) the survival rate decreases by 80-90% with the absence of bystander CPR and delay of 6-7 minutes until on-site AED use is performed; (5) the survival rate decreases by 90-95% with the absence of bystander CPR and delay of 8-9 minutes until on-site AED use is performed. This implies that for an individual VVT/VT patient with an appropriate bystander response (including alert of the EMS dispatcher centre and CPR) the magnitude of the survival benefit from an on-site AED largely depends on the EMS intervention interval. As the mean EMS intervention interval in Belgium is 7 minutes and assuming that AED use takes place 2 minutes before arrival of the EMS, the survival rate decreases by 30-50% with the absence of bystander CPR. This is in line with other studies that show a survival rate of 15-20% if CPR is performed immediately and accurately, and 30-40% when CPR is performed.

From these data, we can assume for Belgium that VVT/VT cases in a school setting will not result in increased survival rates if an on-site AED use is performed. This explains that in the Neonatal Registry for AED use in Sports, Drezner et al. identified 36 cardiac arrest cases between December 2006 and July 2007, 14 among students (63% high school students and 37% non-students, respectively). For VVT/VT cases with known intervention time, the time from arrest to the first shock by an on-site AED ranged from 30 to 195 seconds (with 17 survivors among 23 patients). In the two cases only treated with an EMS defibrillator, the time interval from arrest to the first shocks was 88 and 90 seconds, respectively. In both patients, the duration from collapse to first shock by an on-site AED was 2 minutes and 3 minutes, respectively. In the registry revealed that 85% of students (20/24) and 50% of adults (5/10) survived to hospital discharge. Of the 19 cases where a shock was delivered off-site, 8 (42%) survived, survival rates were 69% (6/9) if the school supplied the AED used in the resuscitation versus 43% if the defibrillator was brought to the patient by responding off-site EMS12. In the CARES registry, the survival rates among school-related cardiac arrest cases was 91% (4/4) in one case where a shock was delivered by a bystander. In 2 cases, no shock at all was delivered by the bystanders 8. No explanation was given for the omission of AED use or shock delivery by the bystanders in both studies8,19. In the Osaka Project is the finding that in only 5 of the 36 cases an explanation was reported: delayed recognition of cardiac arrest due to cardiac activity – as opposed to sudden cardiac death – and collapse after the school day with bystanders being present in the nearby presence of an AED. No indicators for in-school use were found, as the bystanders were not trained to use the AED. On-site AED use was applied to at least 50% in the National Registry for AED use in Sports, and in at least 20% in the CARES registry. For both registries, we found that the survival rate among students and non-students (9/14 and 14/22, respectively) was higher in schools equipped with AEDs (80% (9/11) in comparison with 40% (5/12) in schools without AED use12).
Costs of school-based AED projects

Costs mainly involve AED purchase or lease (including adjuncts such as pads, batteries and protective covers), the training and retraining of all staff. For an accurate search, estimates for Belgium can be made**. AED and adjuncts cost on average 1 800 - 2 300 EUR (without taxes). Annual expenses are a theft/damage insurance fee of 50 EUR and maintenance costs of 150 EUR. AEDs can also be rented from about 30 EUR per month. Costs for the initial training vary from 35 to 87 EUR per person, or from 250 to 300 EUR for the group retraining. In comparison, the annual costs for retraining per trainee (in the long run) amount to about 10% of the initial training.

Important additional factors to calculate the total costs of an AED project are the number of trainees and AEDs required on the campus, and the need for reimbursement of costs arising from cardiac arrest (both students and adults). For example, the placement of an AED project would imply an annual cost of at least 6 600 EUR or 660 EUR per year. As there are about 500 schools in Belgium, a national AED project may cost about 3 960 000 EUR, resulting in 5.4 lives saved.

Moreover, the replacement of a school-based AED programme only has the additional number of surviving students to benefit. In the long run, this number could be increased by using school-based AEDs also for the campus. In this case, schools may only be spent once. Indeed, governmental funding is largely redundant as money (irrespective of the source) may only be spent once. Indeed, governmental authorities and private foundations donating AEDs to schools may not support other projects (e.g. concerning tobacco, alcohol, obesity, bullying and small-scale theft) that in the long run may not mean much.

Further, it should be noted that the results described above are subject to several limitations.

First, correlations on outcomes are based on many assumptions and extrapolations. As most studies were performed in North America and Japan (** countries with advanced educational systems and EMS systems, and differences in prevalence and incidence of cardiac diseases), various studies may be biased if similar studies are to be performed in other geographical areas. Second, the number of survivors among people present on the campus may be regarded as an overestimation leading to flaws regarding the location, accessibility and maintenance of the devices, as well as denominator, knowledge and training of the caregivers.

Furthermore, the benefit could be increased by using school-based AED programme only via the additional number of survivors, quality of basic CPR and accuracy of AED use. The quality of basic CPR may range from 50% to 100% (depending on the school), whereas the accuracy of AED use may be around 75%. Indeed, school-based AED on-site may result in 4.2 survivors (i.e. 30% survival rate in students, and 12% survival rate in adults) and an estimated additional cost of 3 000 EUR per school. Thus, a national AED project would imply an additional cost of 10 800 000 EUR, resulting in 4.8 lives saved.

Fourth, we were only able to estimate costs per life saved. Furthermore, the costs to undertake the costs effectiveness of a particular health care intervention may costs per quality adjusted life year (QALY), which were computed out of values ranging from 10 000 to 100 000 EUR per QALY**. Important to note for AED projects in schools is the opportunity to save youngsters
who may survive for more than 30 years. This may justifiably raise the question of additional long-term complications and the need for continued monitoring. We acknowledge the limitations of our study, such as the lack of evidence on the occurrence and causes of sudden death in swimmers, which was also noted by the investigators of the recent study by Buroker et al. [13].

While the incidence of sudden cardiac death among students may vary from study to study, our results suggest that the incidence may decrease as the retirement age increases. On the other hand, the incidence may increase as the retirement age decreases. Our findings are consistent with previous studies that have shown a decrease in sudden cardiac death among middle-aged adults [14].

CONCLUSION

Our mathematical model based on literature data indicates that school-based AED programmes are feasible and may save a few lives annually in Belgium. Further research is needed to determine the most cost-effective location for AEDs in schools and to assess the impact of AED programmes on the incidence of sudden cardiac death in students.

REFERENCES
