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Automatic external defibrillator (AED) location – seconds that save lifes

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Abstract

Introduction and objective Sudden cardiac arrest (SCA) is a significant cause of adult mortality, categorized into in-hospital (IHCA) and out-of-hospital (OHCA). Survival in OHCA depends on early diagnosis, alerting Emergency Medical Service (EMS), high-quality bystander resuscitation, and prompt Automatic External Defibrillator (AED) use. Accelerating technological progress supports faster AED retrieval and use, but there are barriers in real-life OHCA situations. The study assesses 6th-year medical students' ability to locate AEDs using smartphones, revealing challenges and proposing solutions.

Material & Methods The study was conducted in 2022–2023 at the Medical University of Lodz, Poland. Respondents completed a survey on AED knowledge and characteristics, followed by a task to find the nearest AED using their own smartphones. As common sources did not list the University AEDs, respondents were instructed to locate the nearest AED outside the research site.

Results A total of 300 6th-year medical students took part in the study. Only 3.3% had an AED locating app. Only 32% of students claimed to know where the AED nearest to their home is. All 300 had received AED training, and almost half had been witness to a resuscitation. Out of the 291 medical students who completed the AED location task, the median time to locate the nearest AED was 58 s. Most participants (86.6%) found the AED within 100 s, and over half (53%) did so in under 1 min.

Conclusions National registration of AEDs should be mandatory. A unified source of all AEDs mapped should be created or added to existing ones. With a median of under one minute, searching for AED by a bystander should be considered as a point in the chain of survival.

Keywords Automatic External Defibrillator, AED, Cardiopulmonary resuscitation, CPR, Chain of Survival, Prehospital Care

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Text box 1. Contributions to the literature

There is a lack of research on the feasibility of locating AEDs. In cardiac arrest emergencies, every minute matters, and good markings of places where AEDs are located can save many lives. In an era of widespread access to telephones, the time to provide assistance with a defibrillator should be as short as possible.

Introduction and objective

Out-of-hospital cardiac arrest (OHCA) is a global public health problem with wide variations in frequency and disappointing survival outcomes [1]. The main cause of cardiac arrest is irregular heart rhythm with its most common manifestation being ventricular fibrillation. It can also occur from non-cardiac causes such as asphyxia, trauma, drowning, drug overdose, electrocution and primary respiratory arrests [2]. Bystander Automated External Defibrillator (AED) use before emergency medical services arrival in observed public OHCA was associated with better survival and functional outcomes [3]. Each minute is valuable in lifesaving to avoid irreversible neurological changes and increase the chances of survival. Even though we can't change the place where OHCA occurred, we have an impact in finding and using AED promptly.This is why good labeling of the location is crucially important, and for this to be accomplished, it is important to ensure that it is at the desired level.

The aim of the study is to test the effectiveness in tracking down the nearest AED using cell phones among final-year medical students. The secondary objective is to point out the problem of inaccurate AED identification on the Internet, which has a significant impact on the time with which defibrillation is undertaken. We believe that our study exposes the issue in Poland and will increase the survival rate of victims of cardiac arrest by hastening or increasing the use of AEDs.

Materials and methods

The research was carried out in Clinical and Didactic Center at Medical University of Lodz located on Pomorska 251 street in Lodz, Poland during the 2022/2023 academic year – September 2022 – June 2023. The building itself has had multiple AEDs inside and the closest ones located from it were:

1. Shopping Center M1 Lodz located **3.0 km away** – according to Apple maps.
2. Faculty of Mathematics and Computer Science at University of Lodz located **1.8 km away** – according to the government backed Open Street Map.
3. 3rd Students dorm "Pretor" located **1.2 km away** – according to Google maps.
4. Thread Factory "Ariadna SA" located **0.95 km away** – according to Ratuj z Sercem app.
5. Clinical and Didactic Center located **0.0 km away** – according to Staying Alive app.

The choice of assessing 6th year medical students was warranted as the group consists of people soon to be entering the medical workforce, which are prone to be undertaking resuscitation action if nearby and theoretically more active in procedures aimed at saving someone's life. Also, the group is young, which leads to the majority of them possessing and knowing how to use internet on their smartphone. In the Faculty of Medicine in Lodz, the students have had obligatory 12 h of BLS training in a simulated environment, where one of the main skills taught, is the AED handling. All these factors combine in 6th year medical students being the "perfect" bystanders when it comes to first aid. Based on these preassumptions we have formulated inclusion and exclusion criteria accordingly.

Inclusion criteria:

- Being at 6th year medical student at the time of the data collection.

Exclusion criteria:

- Age under 18 years old.
- Not meeting the inclusion criteria.

The respondents were tasked with completing a short survey. The survey consisted of the questions regarding respondents' characteristics, as well as 6 multiple choice questions regarding their knowledge of AED handling and location. The process of creating and evaluating the questionnaire was as follows:

Stage 1. — Literature review to identify range of problems used in research on similar topics, including literature reviews, original articles, guidelines and international recommendations.

Stage 2. — Preparation of a list of questions and tasks appropriate to verify the chosen aims of the study.

Stage 3. — Evaluation of the content by medical professionals ($n=10$) and medical students (participants, $n=10$).

Stage 4. — Implementing improvements suggested by people who took part in study on Stage 3.

Stage 5. — Completing the evaluation of the questionnaire.

After completing the survey, the interviewees had to locate the closest AED using their smartphone as fast as they could, while one of the researchers was measuring the time. The choice of letting respondents use their own smartphones, instead of having all of them use the same one was made because the situation had to resemble a sudden need to find an AED – the same as the situation when someone is in need of CPR. In these situations, everyone needs to work with the tools they have, and the variability of the smartphones used in this simulation is more accurate in resembling the real world.

Due to the fact that most of the commonly used sources have not included the Clinical and Didactic Center as a place where an AED is obtainable, the respondents were asked to locate the closest AED outside of the place of research instead – therefore the AED located closest and outside according to Staying Alive app was the Thread Factory “Ariadna SA” located **0.95 km away**.

The statistical analysis was carried out using TIBCO Statistica (TM) 13.3.1 programme. Descriptive statistics were used to determine the proportions between the respondents, as well as means and medians of the time to locate AED. Afterwards Mann-Whitney-U and Kruskal-Wallis tests were used to compare age and gender groups against each other.

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Results

Characteristics of respondents

436 Respondents have participated in the research, out of which 300 were 6th Year medical students. Rest of the respondents, who consisted of medics, students of different faculties and years and non-medical professionals have not met the inclusion criteria and therefore have been excluded from the analysis. The median age was 25, whereas the mean equalled 24.9. Other characteristics of respondents can be found in Table 1.

Survey analysis

When analysing only students, it turns out that only 10 (3.3%) of them have had an AED locating app on their smartphone, with 4 of them having a “Staying Alive” app, making it the most popular one.

Only 96 (32%) students were sure about the location of the AED nearest to their home, while 70 (23.3%) claim to have a vague idea about its location. The knowledge about the nearest defibrillator was even lower when the students were asked about the device nearest the place of the research, which happened to be one of the main University buildings, in which the students have spent multiple hours over the last 6 years. The response had shown that only 72 (24%) students had known where the AED in the building was located, with 102 (34%) not being sure and the rest not knowing.

As expected from medical students, all 300 (100%) of them have had an AED training before – as stated in their university programme – and almost half of them (145, 48.3%) have been a witness to a resuscitation. Almost all of the students (286, 95.3%) were sure about using AED if they were performing CPR, with only 1 person (0.3%) being against using it.

Time to locate AED analysis

5 of the participants had no Internet, 1 had no smartphone and 3 surrendered while trying to locate the closest AED. Those 9 (3%) respondents have been removed from the time consumed while searching for an AED analysis. After excluding those who have failed to complete the task, the following 291 medical students tried to locate the closest AED on their smartphones as fast as possible.

The median time was 58 s with mean being 65.4 s. The majority (252, 86.6%) have managed to locate the nearest AED with the web page or mobile application they have decided to use within 100 s and over a half (159, 53%) managed to do so in under 1 min. Time in 20 s intervals is shown on Fig. 1. The AED located varied, being one of the four in the nearby area, shown on Fig. 2.

There was no normality, as the Shapiro-Wilk test was statistically significant ($p=0{,}0000$). After deleting 3 extreme outliers, the normality test was still showing that there is no normal distribution among the results, therefore non-parametric tests have been used: Mann-Whitney-U and Kruskal-Wallis. There was no significant difference when checking for age. Males were more likely

Table 1 Characteristics of the respondents

Characteristics of the respondents			
Variable	Subgroup	n	%
Gender	Male	111	37.0
	Female	189	63.0
Age	Between 23–26	283	94.3
	Other (27–38)	17	5.7
Level of Education	Middle	292	97.3
	Higher	7	2.3
	Work Technical	1	0.4

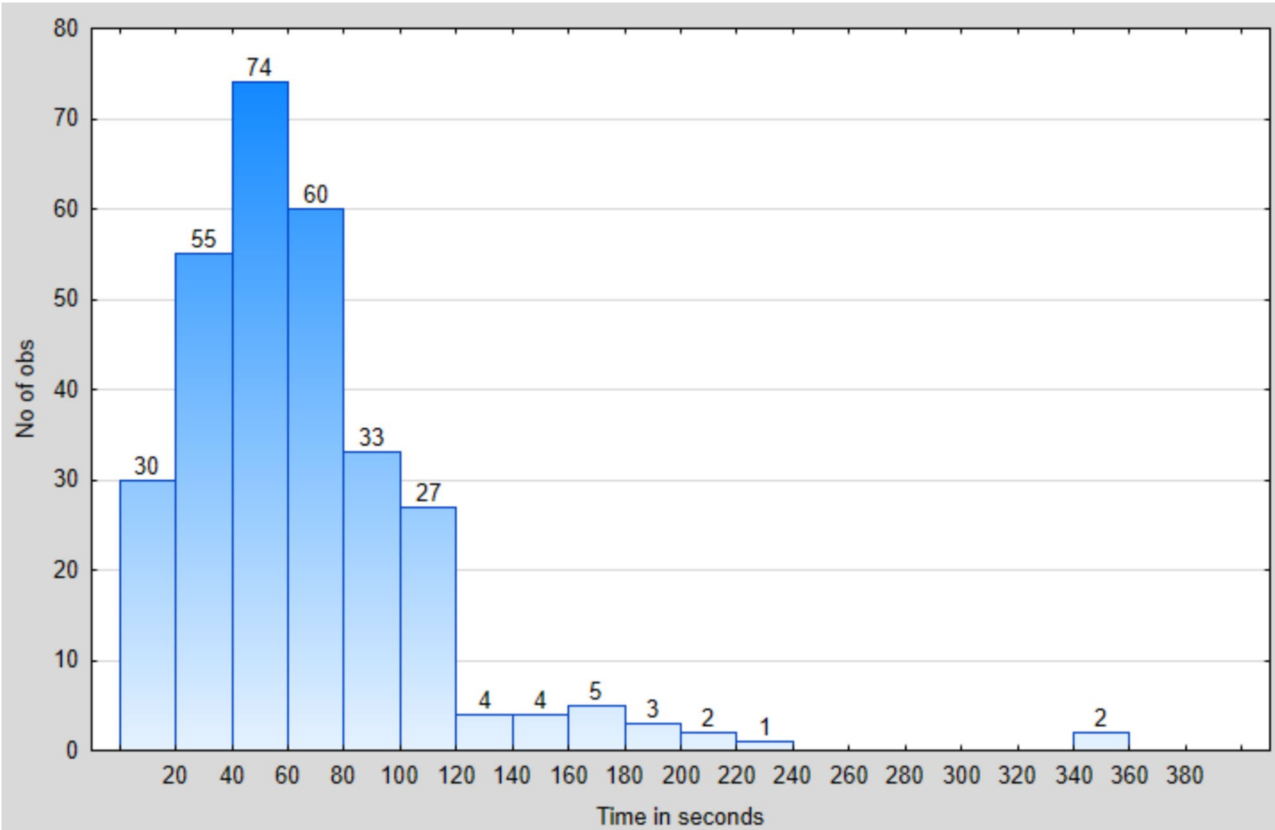

Fig. 1 AED location time by medical students

to have had a mobile app locating AED than females (p=0.0279).

Discussion

Sudden cardiac arrest (SCA) is a significant cause of mortality among adults [4]. Depending on the place of occurrence, SCA is divided into in-hospital (IHCA) and out-of-hospital (OHCA) [4, 5]. This division is important from the perspective of the various causes of SCA, its electrical mechanisms, the possibilities of its prevention and the treatment algorithm itself. In the case of such a division, the hardware capabilities and characteristics of the people performing resuscitation will also differ [6, 7]. In the case of IHCA cardiac arrest, it will almost always be medical staff with more or less advanced equipment and logistics (e.g. specialist laboratories available in the unit, such as invasive cardiology or extracorporeal membrane oxygenation). In the case of OHCA, the situation is completely different. Many SCAs in adults occur at home, and some occur at work or in public spaces (e.g. shopping malls, cinemas, swimming pools, airports, museums, railway stations, hotels, recreation areas, etc.) [4]. Therefore, most often, witnesses of OHCA are bystanders without medical education and with very varying degrees of training in resuscitation [8, 9]. The survival rate and good neurological outcome of OHCA victims are influenced by early diagnosis, alerting the emergency medical services (EMS) system, providing high-quality resuscitation by a bystander, and the use of an automatic external defibrillator (AED) as soon as possible. Especially in this group of patients with OHCA, in which the first rhythm to occur is a shockable rhythm [5–7]. The implication of this fact was the implementation of public access to defibrillation programs (PAD) [10]. The idea is to place defibrillators in areas where the risk of OHCA is justified. Additionally, accelerating technological progress is constantly creating new potential opportunities that will ultimately lead to faster use of AEDs [11, 12]. Unfortunately, statistics and the real-life history of many situations related to OHCA in public spaces show that the use of an AED that could potentially be available on site encounters many barriers [13–15]. One of them is that other people are unaware that there is a defibrillator nearby. This leads to the failure to use the device and a break in the “Chain of Survival” of this critically important third link [16, 17]. The aim of the current study was to assess the ability of 6th-year medical students to determine the location of the closest AED.

The work was intended to assess knowledge about the location of defibrillators located at the place of teaching

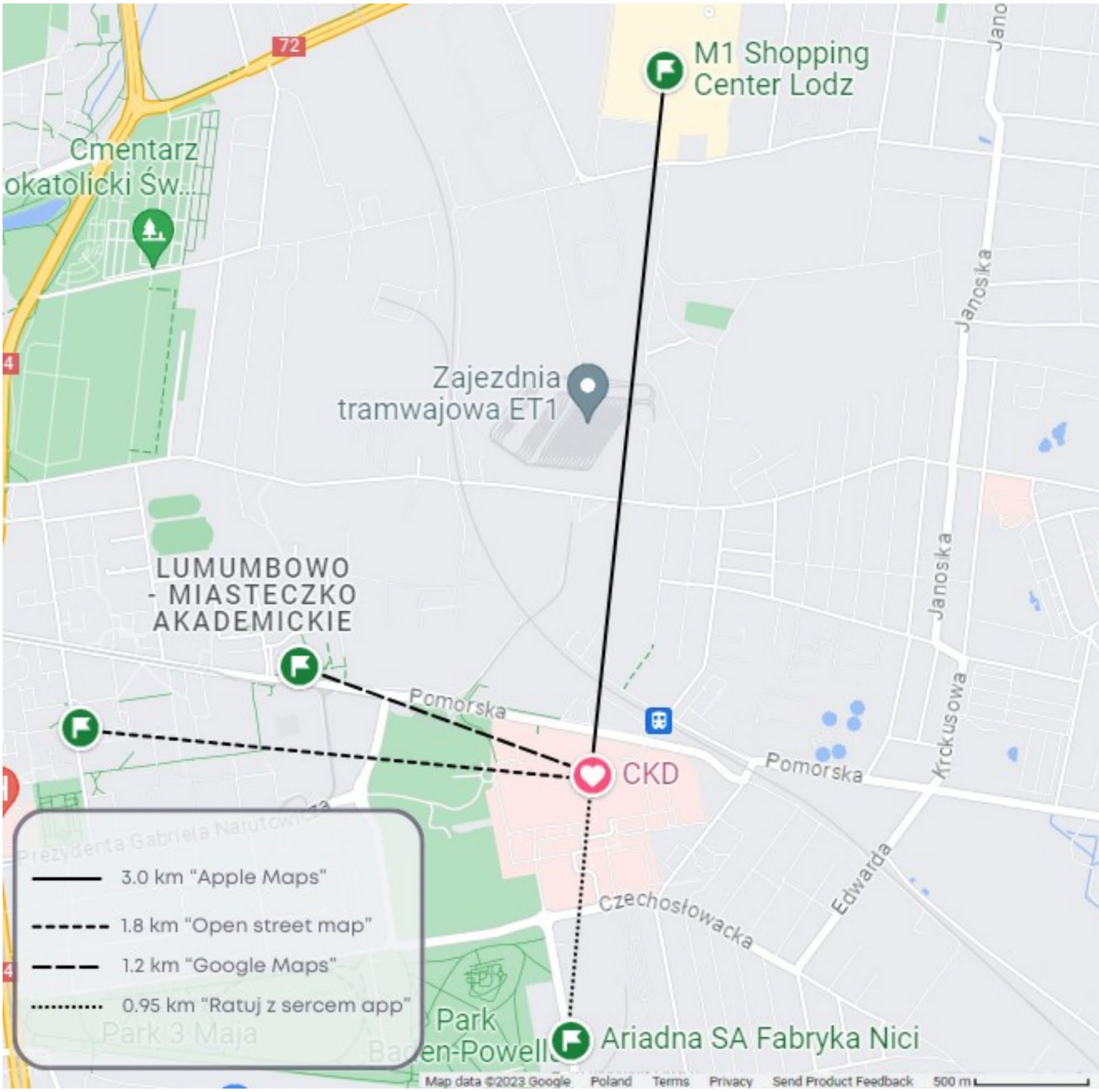

Fig. 2 AED distance shown by most popular web pages/mobile applications

classes and to assess the ability to find other devices that may be nearby using a smartphone. This is possible thanks to the existence of applications that are based on data kept by their creators and determine the location of nearby AEDs. Applications of this type alone are not novelties [18]. However, their use in practice and their use as a potential tool for faster location of a device that can be used to perform quick defibrillation have only recently become a topic of research [19–22].

The placement of defibrillators and the potential for widespread availability are difficult topics. For example, due to the need of financing for the purchase of equipment maintenance. Additional costs are also generated by situations in which defibrillators are available outside buildings. This requires placing the AED in more expensive cabinets with ventilation and heating. The second issue is the availability of AEDs in the most common places of cardiac arrest in adults - at home [4–7, 19, 23]. In this regard, solutions are being sought that involve delivering a defibrillator to the home where it is located. This concept could be based on First Responders or use Drones [23–27]. Of course, in both cases it is necessary to use an effective communication response system starting with the medical dispatcher [21, 23, 26, 27]. The next issue concerns knowledge about defibrillators located nearby. This is particularly important in the case of devices that are available and can be potentially delivered within a short time [21, 25, 27, 28]. In the current study, the median time to successfully locate the nearest AED indicated in mobile applications or using dedicated websites (maps) was 58 s. The assessment of whether it was a short or long time remains controversial. This is a parameter strictly dependent on the tool used, which creates gaps in knowledge and makes it difficult to realistically assess the impact of mobile apps [23, 25, 28]. In the study by Neves et al., the median time to perform a simulated shock for the group using a specific smartphone app was 9:44 min, IQR 6:30 – 10:00. Relative to this total time point based on clinical logic, a median of just under a minute may not seem long. It is worth noting, however, that participants from the study group used various tools of their choice available in Poland. On the one hand, this may constitute a limitation of the study. On the other hand, it may lead to a conclusion from the current study that is important from a practical perspective. None of the online AED maps used by the respondents had information that the nearest defibrillator was located in the same building where the examination took place (exactly 3 devices). Only 3.3% of respondents with the STAYING Alive app could confirm with a smartphone the actual location of the nearest AED - in the building where they were at the time of the task. Additionally, it is worth noting that before the "locate the nearest AED using your smartphone" part, only 24% of respondents were aware of the availability of defibrillators in the building. This may indicate the low effectiveness of applications and websites run by various organizations, foundations or even the government website. In relation to this problem, the lack of legal regulations regarding reporting the location of AEDs may be important. Even more so because some of these devices do not belong to the local PAD system, but only to companies, organizations or institutions that financed the purchase of the device with their own funds. It would therefore be necessary to solve these problems locally and globally [28]. Perhaps the introduction of legal regulations encouraging participation in a centralized register in exchange for financing the costs of potential use of AED from public funds. These issues need to be considered carefully and adapted to regional conditions. As shown by the scoping review by Valeriano et al. even with regard to systems relating to volunteer first responders and their alerting, there is huge variation in the solutions used for example HeartRunner in Sweden, PulsePoint Respond in USA or GoodSAM in United Kingdom [29]. Valeriano et al. review identified more than 25 unique smartphone based crowdsourcing technologies used in 23 countries. The authors emphasized that despite the spread of this technology, high-quality data on the effectiveness of these applications is limited. In addition, the effect in the form of AED can be different. In the case of HeartRunner, an increased frequency of defibrillation in OHCA has been demonstrated before the arrival of EMS in public and residential locations [12, 30]. On the other hand, Berglund et al. In Samba Randomized Clinical Trial indicated that smartphone dispatch of volunteer responders (Heartrunners) to out-of-hospital cardiac arrests with instructions to retrieve nearby AEDs, compared with instructions to perform CPR directly, did not significantly increase the bystander attachment rate [31]. The current study was attended by students of 6 years of medicine, and therefore a selected group constituting both the young generation and in theory showing the highest awareness of generally understood healthcare. It is certain that all technological solutions that are to facilitate the location of AED, its availability or direct delivery to the victim require thorough analysis and adaptation to the prevailing conditions. As the results of the current study show, not all solutions show the same effectiveness. In addition, the awareness of the automatic defibrillators nearby requires analysis throughout the local population and potential interventions.

It is highly alarming that in such a theoretically aware group of as many as 68% of respondents do not know where the defibrillator's closest to their home is and 74% is not aware of the location of the AED in the building where they have been studying for several years. The low effectiveness of AED maps available on the Internet due to large deficiencies in recording devices and low awareness of respondents regarding the location of defibrillators in their immediate surroundings should pay attention to the human factor in the whole issue. Perhaps in future studies, apart from the effectiveness of systems and applications, as well as technological solutions to answer holes in knowledge, it is worth looking for just from this perspective. Therefore, it is worth considering more emphasis on the popularization of the very awareness of not only the clinical essence of defibrillation but the importance of knowledge about the location of AED in the nearest environment and awareness of the selection of effective tools in each region facilitating this process. The human factor can also be incredibly important in promoting and encouraging decision-makers and the whole society to report and register devices that they see in public space. All this must of course be supported by real coordination with systemic solutions and those that focus on the financial sphere of the issue.

This study has two main limitations. First of all, the available AED mapping sources have shown different results from the very beginning. This is a systemic problem, however it could be the subject of a new, similar study which would require people to find a source saying that an AED is in this place, which would by all means prolong the searching time. Respondents were also tasked to use their own phones, which makes the results more varied, however the belief was to create a situation which would be as close to real life as possible.

Conclusions

As a result of the considerations and analyses, the following conclusions were formulated:

- National registration of AEDs should be mandatory.
- A unified source of all AEDs mapped should be created or added to existing online available maps.
- If there are multiple bystanders, one should be delegated to search for a nearby AED.
- Asking a bystander to search for a nearby AED should be included in a Chain of Survival.

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Author contributions
Research concept: W.T. D.T.Research methodology: D. T.Collecting material: J.K. D.T.Statistical analysis: W.T.Interpretation of results: W.T F.J. J.K.References: W.T. F.J.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study received approval from the bioethics committee of the Medical University of Lodz (RNN/244/22/KE). Participants were adults and the participation in the study was voluntary.

Competing interests
The authors declare no competing interests.

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