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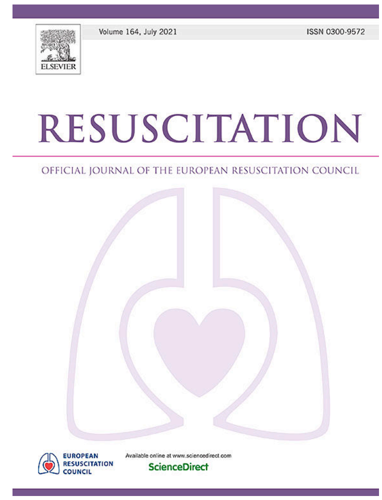

Original paper

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Turnout Time in Smartphone Alerting Systems: Underestimated Entity in the Development of Smartphone-related Dispatch Algorithms.

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Language check

During the preparation of this work the authors used DeepL write and OpenAI ChatGPT 2025 to check language and readability. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Abstract

Introduction Smartphone alerting systems (SAS) for out-of-hospital cardiac arrest (OHCA) are requiring continuous further development. One important element herein is the algorithm, dispatching only those community first responders (CFR) capable of reaching the scene within the shortest possible time. Currently, no data exist regarding the interval between the initial alert and departure to the scene (=turnout time, ToT), despite the critical importance of this information for optimizing dispatch algorithms.

Methods In this retrospective observational study, 4,138 operations of CFR who participated in the SAS "Region of Lifesavers" between 01 August 2023 and 15 March 2024 were analysed. Upon receiving an alert, a CFR smartphone was tracked via Global Positioning System (GPS). Turnout was recorded when the device left a fenced area of 20 meters from the alert acceptance point. Ethical approval was obtained (DRKS00032957).

Results The median ToT was 1:45 minutes, which corresponds to one third of the response time (1:45 of 5:22 minutes). Nighttime had the strongest influence, with significantly longer ToT (2:22 min) compared to daytime (1:42 min, $p < 0.001$). The day of the week, mode of transport, and assigned task had a minimal impact.

Conclusion The ToT has a relevant proportion of the response time until CFR arrive at the scene. Relevant factors influencing the ToT were identified and should be taken into account when developing smart alerting algorithms to ensure the efficient dispatch of CFR.

Key words: first responder system, intelligent dispatch, cardiac arrest, automatic external defibrillator, emergency response system

Introduction

Out-of-hospital cardiac arrest (OHCA) is a time-critical event associated with high mortality. Smartphone alerting systems (SAS) have been implemented to minimise the time until first chest compressions and defibrillation initiated by community first responders (CFR) who are in the vicinity of a suspected OHCA. Smartphone apps can be used to locate CFR using the Global Positioning System (GPS), alert the CFR and navigate them to the scene or a public available automated external defibrillator (AED), respectively. The current guidelines of the European Resuscitation Council (ERC) recommend the use of systems with geo-referenced alerting in the event of cardiac arrest [1]. However, these systems differ in their conceptual implementation and technology [2,3]. Recent development comprises modern algorithms with the objective to alert those CFR with the shortest possible travel times [4,5]. In an ideal case, the algorithm activates only those CFR, who can arrive at the scene prior to the ambulance. Former studies revealed that app-based alerting is associated with shorter response times as compared to text message alerting [6], and that an algorithm selecting CFR based on their anticipated travel times can further reduce response times [5,7]. For the continuous improvement of alerting software standardised reporting of process times is required. This can be realised applying the reporting standard for describing first responder systems [8].

CFR response time, defined as time from emergency alert to arriving on scene, consists mainly of two relevant time intervals: 1) the time until traveling (i.e. get dressed, leaving the house, get into the car), and 2) the travel time. With response times being shorter than 5 minutes and assuming that the CFR may need three minutes until running or driving to the scene, the turnout times (ToT) may contribute substantially to the response times (**Figure 1**). To our knowledge, no studies have investigated ToT of volunteer CFR alerted by smartphone [9] and its relevance and effects on process times until today. A deeper understanding of influencing factors of ToT is needed in order to apply this knowledge in the development of future dispatching algorithms. This study seeks to quantify the ToT and to identify and characterize potential factors influencing this time interval.

Methods

Setting and study design

This retrospective observational study was conducted from August 1, 2023 to March 15, 2024, in 12 regions, in which the "Region of Lifesaver" (RoL) system had been implemented for more than six months. These regions cover a total of 19,061 km² and a population of 4,540,577 Inhabitants (dispatch centres: Kempten, Calw, Emmendingen, Freiburg, Heilbronn, Ludwigsburg, Altena, Rastatt, Offenburg, Hoyerswerda, Schwaebisch-Hall, Villingen-Schwenningen). Most regions were rural, two regions have cities with more than 100,000 inhabitants (Freiburg, Heilbronn). 7,917 CFR were registered in October 2023 and 8,381 CFR in March 2024.

Smartphone alerting system (SAS) and community first responders (CFR)

The system “Region of Lifesavers” consists of a smartphone app and the associated server software, which is connected via a software interface to the respective regional dispatch centre. The "Region of Lifesavers" pilot project was launched in Freiburg in 2018 and rolled out to other regions in Germany [10]. Effective May 2025, the system has been established in 77 regions with 16.6 million inhabitants and covering 65,000 square kilometres. Registration as volunteer CFR requires at least a basic paramedic qualification or training in a healthcare profession and regular participation in resuscitation training. Most volunteers in our system are from hospitals, emergency services, fire brigades, police, and other organisations experienced in dealing with emergencies.

Alerting procedure

In case an emergency call is received with a suspected cardiac arrest or an unconscious person, the dispatch centres operation control system suggests activation of the SAS in addition to the regular response. The system is not activated in cases of trauma, dangerous situations, or incidents occurring within care or healthcare facilities. The global positioning system (GPS) position data of the emergency location and the estimated time enroute (ETE) for the ambulance are sent to the RoL backend system. CFR positioned close to the emergency location are alerted through a “pre-alert” which is a loud sound even if the smartphone is in do-not-disturb mode, and first responders are requested to respond. Each responder indicates whether he or she is available, the personal means of transport (i.e. car, bicycle, by foot) and whether he or she carries an AED. For each responder, a route calculation to the emergency site is done based on the respective means of transport. If the anticipated travel time is greater than the ambulance ETE, the alert is cancelled for the respective first responder. Those two CFR with the shortest calculated travel time are directed to the patient to provide chest compressions and ventilations, while a third responder is instructed to get an AED, indicated by the app. This task is only distributed if there is an AED nearby the emergency location and if the travel time to the AED location and then to the emergency location is shorter than the anticipated ambulance ETE. A fourth CFR is directed to the patient in order to provide directions for the ambulance staff and taking care of relatives or bystanders if needed (**Figure 1**).

The backend system has an interface to the "DEFI-Map" AED database (www.defi-map.de), which contains positions of AEDs, information about how to access the AED including the times of unrestricted access and photos of the AED.

Data collection

The process times were extracted from the backend database and analysed. In case a CFR receives and accepts an alert, the individual smartphone is tracked by GPS for a duration of 20 minutes. The system sends repetitive push messages every 10 seconds to each smartphone of the CFR, who participate in the system, requesting the current geographical position by using the location services of the smartphones. When the position of the CFR's smartphone is logged outside a circle of 20 meters (=geofence) around the position at which the CFR accepted the alert, the respective CFR is logged as "Departed". The time interval between accepting the alert and departing to the scene was defined as turnout time (ToT). When the position of the CFR's smartphone enters a circle of 50 meters (=geofence) around the position of incident scene, the CFR is logged in status "Arrived".

Ethical approval

The trial was approved by the Ethics Committee of the Albert-Ludwigs-University Freiburg and registered with the German Clinical Trials Register (No: DRKS00032957). The data of individual CFR were used based on the end user licence agreement (EULA FirstAED/ Region of Lifesavers).

Statistical analysis

All statistical analyses and visualizations were conducted using R statistic software version 4.3.3, the R packages psych, ggplot2, rstatix, and openxlsx [11]. To test the assumption of normally distributed data, a Shapiro-Wilk test was performed. Process times were compared using a Mann-Whitney-U test. For more than two groups, the Kruskal-Wallis test was performed, followed by a Dunn's test for post-hoc analysis. Data were expressed as medians with interquartile ranges, and $p < .05$ was considered significant.

Results

Of 6,085 alerts, one or more CFR were deployed in 3,216 cases (53%). Up to four CFR are assigned to a task, and 4,138 complete data sets could be analysed (**Figure 2**).

Turnout time (ToT)

The median time interval between receipt of the alert at the backend and alert at the smartphone (=delay time) was 00:03 (IQR 00:02;00:05) minutes (minutes:seconds). The median time interval between the alert and submission of the answer (=acceptance time) was 00:22 (IQR 00:15; 00:33) minutes. The median ToT interval was 01:45 (IQR 01:10; 02:28) minutes. The median time interval between departing and arriving on the scene (=travel time) was 03:18 (IQR 00:56; 05:00) minutes. The overall median response time from receiving the alert to arriving on the scene was 05:22 (IQR 03:52; 07:14) minutes.

The ToT was categorised into 30-seconds intervals to analyse the frequency distribution (**Figure 3**). 18% of the CFR started travelling after less than 60 seconds (n=752). The largest proportion, 42 % (n=1,744), started travelling between 60 and 120 seconds. 1,642 CFR had a ToT of more than 2 minutes.

Influencing factors

The median day-time ToT (between 6 a.m. and 11 p.m.) was 01:42 (IQR 01:08; 02:24) minutes (n=3,781) and the median ToT during night-time (between 11 p.m. and 6 a.m.) was 02:22 (IQR 01:39; 03:24) minutes (n=357). The mean difference of 40 seconds proved to be significant ($p < 0,001$). The distribution of ToT over the course of the day is shown in **Figure 4**.

The median ToT on holidays (Sunday or public holiday) was 01:51 (IQR 01:17; 02:30) minutes (n = 699) and on workday 01:44 (IQR 01:08; 02:27) minutes (n = 3,439). The mean difference of 7 seconds was significant ($p < 0,01$).

The median ToT for CFR who ran to the emergency location was 01:43 (IQR 01:08; 02:26) minutes (n=331), whereas those who travelled by bicycle had a ToT of 01:58 (IQR 01:26; 02:46) minutes (n=218). CFR who drove by car had a median ToT of 01:44 (IQR 01:09; 02:27) minutes (n = 3,589). When comparing the modes of transportation, no significant difference was detected between running and car (mean difference 1 second, p=1). However, the difference between running and cycling (mean difference 15 seconds, $p < 0,001$) and the difference between car and bicycle (mean difference 14 seconds, $p < 0,001$) proved to be significant (**Table 1**).

Discussion

The described data indicates that ToT plays a substantial role in the process from alert until arrival on scene.

Smartphone/app-based systems result in shorter response times in comparison to text message (SMS)-based systems [6,12]. Smart dispatch algorithms may be beneficial to further reduce response times. Current technology advances allow the measurement of precise process times and its integration into algorithms [9,13].

The ToT has been studied in the professional sector of emergency services focussing on process optimization and shortening the turnout time by improving workflow [14,15]. However, this approach does not apply to a SAS, where volunteers respond to in a non-professional manner. Therefore, the focus of the work presented here is different. Aim was to evaluate this previously unknown time interval, its distribution and the related influencing factors with the goal of incorporating the identified aspects into the development of a dispatch algorithm. This is crucial since the predictive capability of such algorithms will be essential for future advancements in dispatching CFR.

It is notable that ToT accounts for a considerable proportion of the total response time, constituting approximately one-third of the total (1:45 out of 5:22 minutes). Consequently, it is very important to acknowledge this time interval and to recognize that the response time in SAS should not be regarded as a single determining parameter [8]. The importance of the ToT is further emphasized by the fact, that the largest proportion occurred between 60-120 seconds (**Figure 3**). It is crucial to recognize that the ToT represents a form of delay, which should be incorporated into existing SAS concepts. In the beginning of the use of SAS, the airline distance to the scene has often been considered as primary variable focusing on the aspect how quickly a CFR can travel the demanded distance [16].

The only published assessment of ToT for voluntary CFR measured the interval from the moment the CFR was requested until the CFR selected "accept the operation" on their device [17]. However, this measurement more accurately reflects the acceptance time rather than the proper ToT. Experts in the field of SAS have already sought to establish standardized definitions [8]. However, the relevance of ToT has not yet been emphasized within these agreements and should, therefore, be explicitly incorporated in future standardization efforts.

Variations in the time of day demonstrated the most pronounced impact on the ToT. During nighttime hours, understandably enough, CFR require significantly more time to depart to the scene.

Looking at the distribution of ToT we found a relevant proportion of CFR with very short ToT below 1 minute (18%). Furthermore, a large proportion has a ToT of more than 2 minutes (40%). One has to realize, that it is not a matter of taking into account a fixed ToT into the alerting algorithm, but rather of dynamically anticipating individual ToT at the moment of alert. The observed variability, including evident outliers, underscores the limitations of a one-size-fits-all approach. Future alerting algorithms should therefore aim to incorporate inter-individual prediction models which account proactively for such variation and optimize the timing and targeting of CFR activation.

However, it is important to note that a) in the used SAS the mode of transport is only determined after the alert has been received and is not available to the system at the time of the emergency call, and b) the observed differences of 15 seconds hold limited practical relevance. The influence of the chosen mode of transport is likely more relevant in the context of travel time rather than ToT. Another relevant aspect is the potential for a substantially reduced ToT, particularly when the formal turnout process is effectively bypassed - for instance, if the SAS can identify CFR who are already in transit (e.g., by bicycle or car) and prioritise them over CFR who are starting from home or work. This highlights the possibility of incorporating contextual indicators into alerting algorithms: The smartphone’s movement speed at the time of alert, GPS precision, or different device settings (e.g., sleep mode, CarPlay mode) may support to anticipate ToT and thus to estimate the individual response time more precisely.

Limitations

The reliance on GPS-based smartphone tracking introduces potential inaccuracies in the measurement of CFR movement and timing. Signal loss, device-specific performance, and user settings (e.g., location permissions) may have affected the precision of recorded process times. The behavior of CFR represents an additional source of variability. The data assume that CFR carry their smartphones consistently and interact with the app reliably. Lastly, this study focuses exclusively on process metrics (e.g., turnout and arrival times) and does not include clinical outcome data. Therefore, no conclusions can be drawn regarding the system's direct impact on patient outcomes.

Conclusion

This study shows the relevant proportion of ToT of one-third in relation to the total response time of CFR in a SAS. The most significant factor influencing ToT was the time of day. These findings underscore the importance of integrating ToT and its influencing factors into smart dispatch algorithms, enabling CFR to be dispatched as efficiently as possible, thereby reducing response times and facilitating faster initiation of lifesaving support.

Figures and Tables

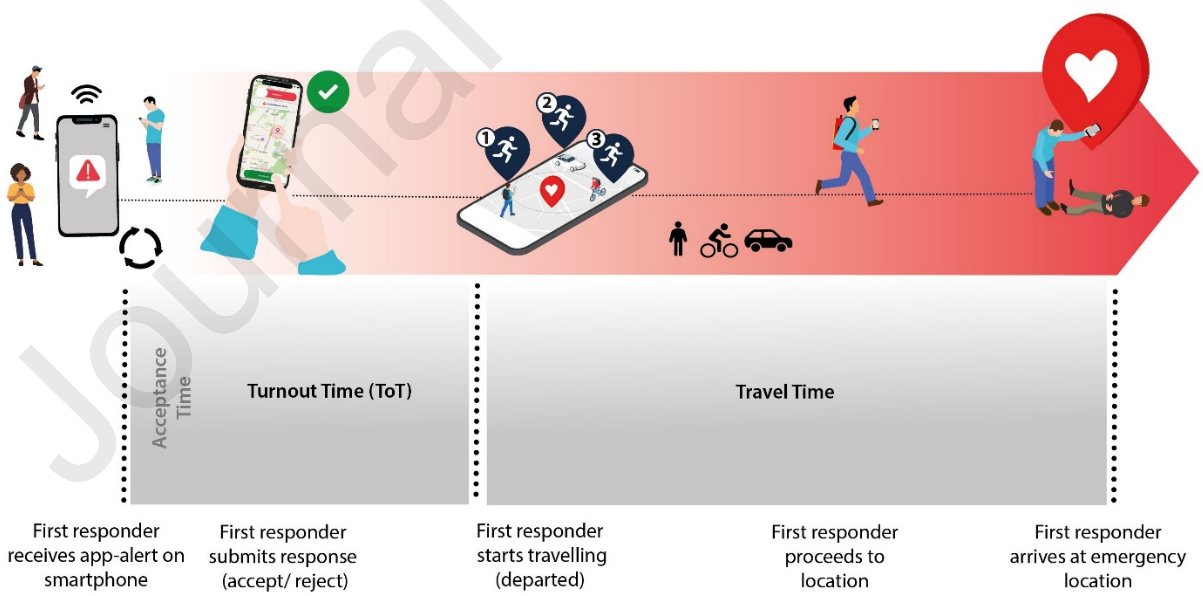

Figure 1 Process times from alert to arriving on scene.

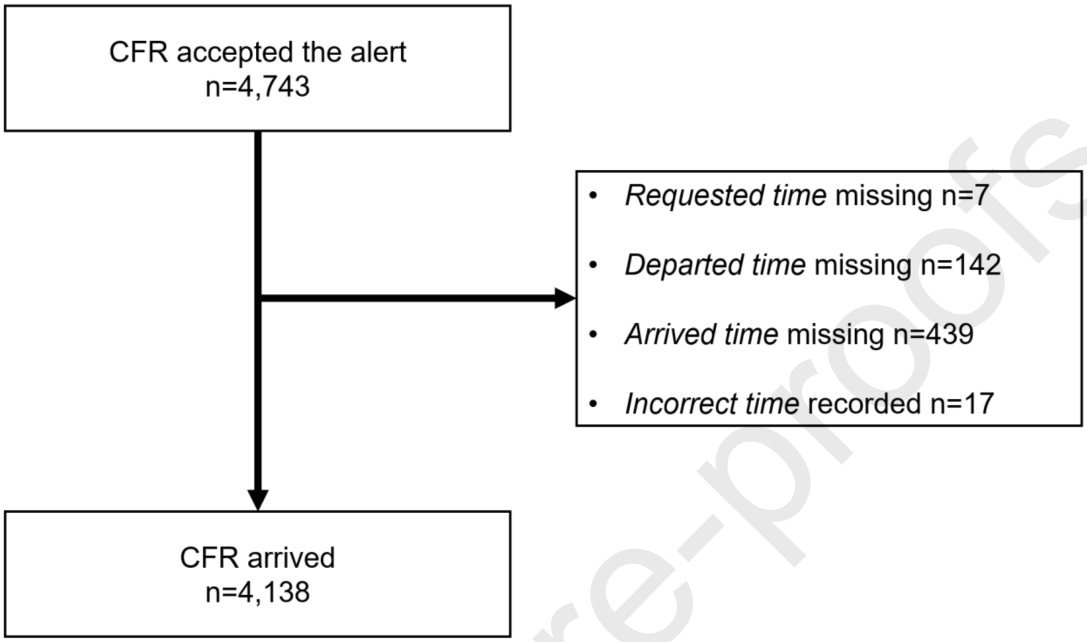

Figure 2 Flow chart with all exclusions. A maximum of four community first responders (CFR) can be assigned to each alert.

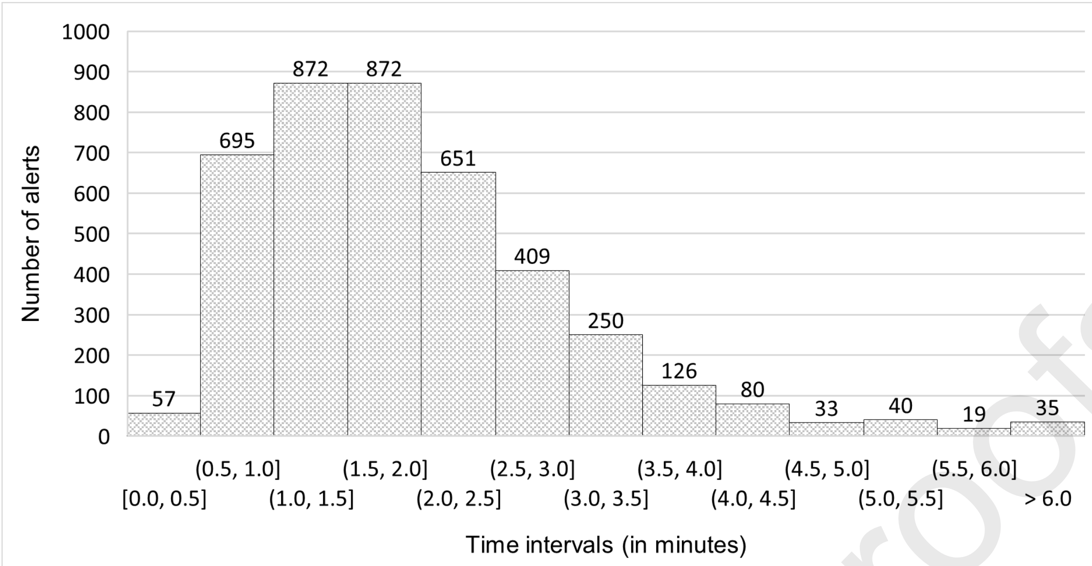

Figure 3 A histogram of all alerts (datasets) divided into time-intervals of 0,5 minutes, n=4,138.

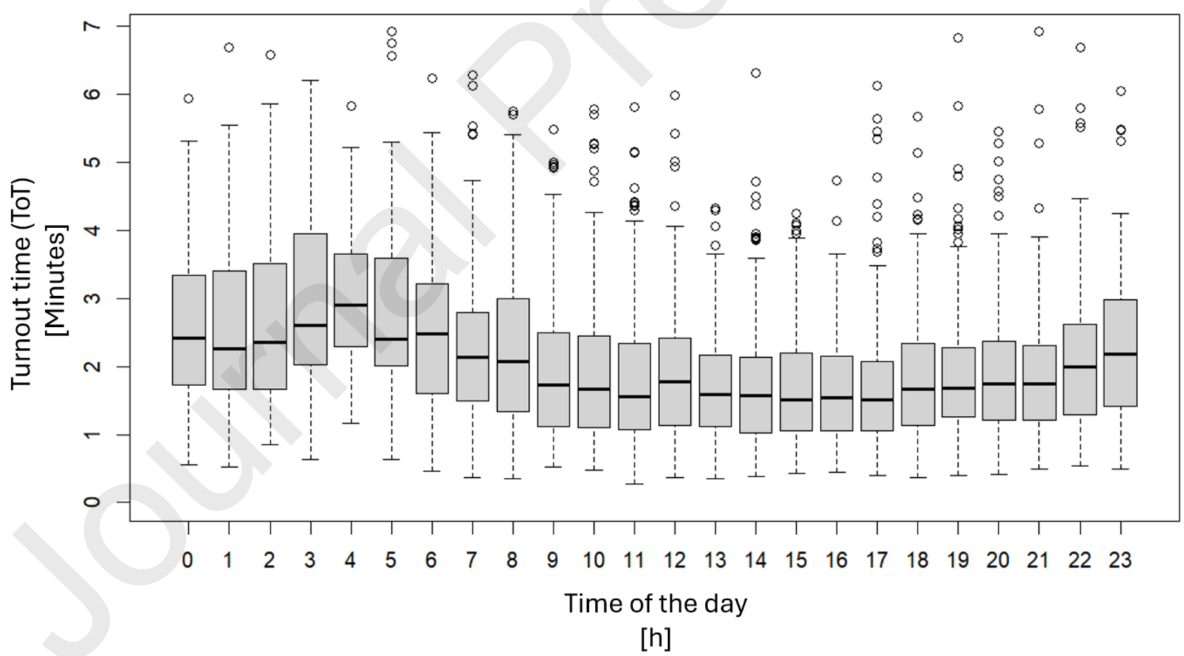

Figure 4 Boxplot of the distribution of ToT over the course of the day.

	Turnout Time (Median)	Q1	Q3	n
Distance: First Responder to Emergency Site				
<500 m	01:49	01:12	02:30	571
500 - 1,000 m	01:45	01:08	02:24	760
1,001 - 2,000 m	01:43	01:09	02:25	1,081
2,001 - 2,500 m	01:39	01:03	01:50	317
>2,500 m	01:48	01:13	02:31	1,408
Time and Day				
Daytime (6 a.m. - 11 p.m.)	01:42	01:08	02:24	3,781
Nighttime (11 p.m. - 6 a.m.)	02:22	01:39	03:24	357
Holiday	01:51	01:17	02:30	699
Workday	01:44	01:08	02:27	3,439
Mode of transportation				
Foot	01:43	01:08	02:26	331
Bicycle	01:58	01:26	02:46	218
Car	01:44	01:09	02:27	3,589

Table 1: The median turnout time (ToT) in (mm:ss) divided in subgroups.

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Resuscitation Journal

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Editor-in-chief

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July 10th, 2025

Dear Prof. Nolan,

The following section provides a clear overview of all COIs disclosed by the authors. The individual statements are attached to the submission.

JG is member of the board of Region of Lifesavers (non-profit organisation).

SM has no conflicts of interest.

JSP: is member of the executive committee of the German Resuscitation Council and part-time employee of Resuscitec GmbH.

HJB is vice chair of Region of Lifesavers (non-profit organisation).

TB received honoraria from FirstAED ApS, Denmark, for technical support regarding FirstAED alerting software.

GT is board member of the German Resuscitation Council and Region of Lifesavers.

MPM is chair of Region of Lifesavers (non-profit organisation).

We are looking forward to hearing from you.

Best regards,

Dr. Julian Ganter

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