Influence of bystander activation on pre-hospital emergency care response time: systematic review

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Abstract

This article presents a systematic review and analysis of grey literature to identify and address gaps in knowledge regarding the role and influence of bystander activation on pre-hospital emergency care (PEC) response time. We conducted a systematic search for full-text articles published since 2000 in Web of Science, PubMed, Science Direct, and Google Scholar databases. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, using "pre-hospital emergency care response time" and "bystanders" as search keywords. The risk of bias was assessed using the ROBINS-I tool. Our analysis included forty-six relevant studies meeting the inclusion criteria. However, we observed that many studies were poorly reported, posing risks of selection and detection biases. Additionally, we identified methodological and study design weaknesses in five studies. Given the critical role of PEC services in saving lives and preventing medical complications, the timely provision of these services is paramount. Bystanders play a central role in activating emergency medical services (EMS) and providing cardiopulmonary resuscitation. Prompt calls to EMS by bystanders resulted in reduced PEC response times, improved survival chances, and better neurological outcomes, particularly among out-of-hospital cardiac arrest patients. There is substantial evidence that prompt bystander activation of EMS significantly reduces PEC response times, thereby saving lives and strengthening existing PEC systems. However, further research is necessary to accurately assess the impact of different interventions aimed at enhancing bystander activation of EMS and reducing PEC response times.

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Introduction

An Emergency Medical Service (EMS) is a system that organizes all aspects of medical care offered in the pre-hospital environment (emergency scene and transport to hospital) and the emergency department as guided by the WHO Emergency Care System Framework (ECSF).[1] To be effective, EMS systems need to be integrated within other health system resources and services for timely service delivery, and minimal chances of morbidity and mortality.[2] Performance of an EMS system is dependent on several aspects, including private and public organizations, health facilities, communication networks, transportation networks, trained professionals, and bystanders.[3] According to WHO, the pre-hospital emergency care (PEC) lineup comprises bystanders, dispatchers, and ambulance teams with health care providers.[4] This study focuses on the bystander as the emergency care system 'activator' who identifies a case as an emergency and calls the emergency operations center (EOC) to request emergency services while receiving instructions from the dispatcher.[5] Of much interest is the haste in which the bystander can comprehend an emergency case and call the dispatcher who should be guided by protocols that are time-sensitive and can reduce EMS response time.[6]

Classically, PEC providers' performance is evaluated based on time taken.[7] PEC response time comprises of notification interval; activation interval; provider response interval; transportation interval; and handover interval.[8] PEC response time is a key prognostic factor for morbidity and mortality especially among out-of-hospital cardiac arrest (OHCA) patients.[9] Many studies have shown that

short notification, activation, and provider response intervals are associated with a high probability of survival to hospital discharge and favorable neurological outcomes among OHCA patients.[10] Noteworthy, implementation of timely emergency care services can address 45% of deaths and 36% of disability mainly in low-income and middle-income countries.[11]

Huang-*et al.* note that bystanders' basic life support knowledge and skills, and calling EOC are the key factors associated with OHCA patients' survival.[12] Additionally, the EMS system, counting the response time, initial treatment at the scene, patient evaluation, along to-hospital-transportation can increase survival rates and neurological outcomes of patients.[13,14] Data still lacks on which interval in PEC response time is more significant in improving survival outcomes considering that other factors like regional variability also come to play.[13,15,16] In developing EMS countries, reducing PEC response time and increasing bystander activity should be one of the priorities in the EMS development process and policy-making decisions. [16-18]

Additional evidence is warranted to establish the potential direction and national policy for EMS system improvement in countries where EMS systems have been recently developed.

Aim of the review

This systematic review and analysis of grey literature aims to identify and address gaps in knowledge regarding the role and influence of bystander activation on pre-hospital emergency care response time.

Materials and Methods

The systematic review process includes the following steps: development of research question; forming criteria; search strategy; searching databases; title, abstract, and full-text screening; manual searching; extracting data; quality data assessment, statistical analysis, and manuscript writing. The review focuses on articles with information on bystander and PEC response time, including full-text articles published from 2000 till 2021 and available in databases/e-journals, such as Web of Science, PubMed, Science Direct, and Google Scholar. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed using "pre-hospital emergency care response time" and "bystander" as search keywords. The risk of bias was assessed with the ROBINS-I tool. PICOS (Population, Intervention, Comparison, Outcome, Study design) approach in quantitative evidence synthesis; and SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research type) approach was used for qualitative and mixed methods search.

"Bystander" was defined as a person who witnesses and identifies a casualty. "PEC response time" was defined as relating to notification interval; activation interval; provider response interval, transportation interval, and handover interval.

Inclusion criteria were: i) the influence of bystanders on PEC response time, ii) studies from any country, and iii) published in English between 2000 and 2021. Exclusion criteria included: i) study with data not reliably extracted, duplicate, or overlapping data; ii) abstract-only papers as preceding papers, conference, editorial, and author response thesis and books; iii) articles where full text was not available; iv) articles published before 2000 and after 2021; and v) studies with statistical issues, without appropriate study design, and with poor quality.

The flowchart depicting each step of the review process is reported in Figure 1.

Results

The initial literature search yielded a total of 552 studies. Based on inclusion criteria, 506 were omitted from the analysis. The remaining 46 studies were selected for analysis as indicated in the *Online Supplementary Materials.*

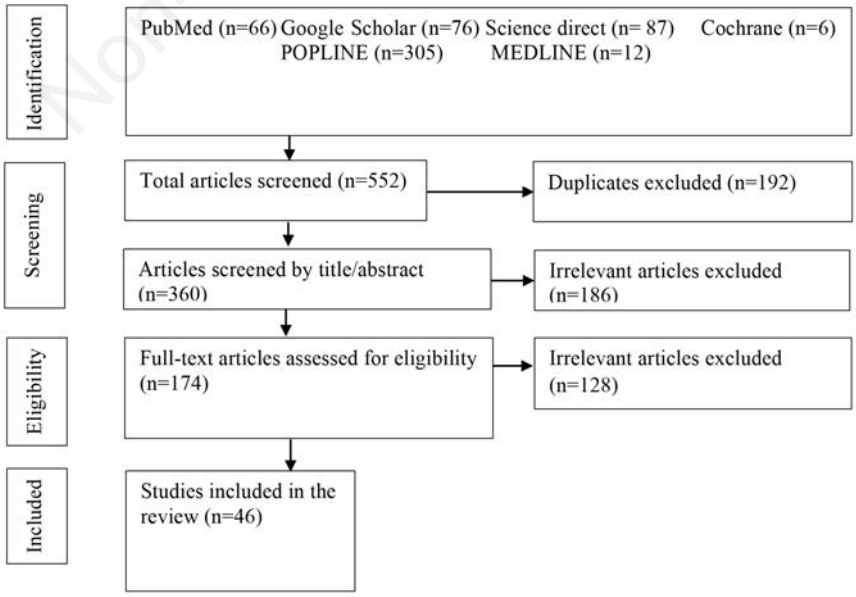

Figure 1. Systematic review flowchart.

Study design

This systematic review includes 46 studies, as follows: 13 cross-sectional studies, 7 cohort studies, 4 prospective studies, 12 retrospective studies, 6 observational studies, 2 descriptive studies, 1 secondary analysis study, and 1 simulation study. Interest in emergency response time has heightened over time. There has been a gradual increase in average publications featuring emergency response time since 2010. Studies on emergency response time and attributable outcomes were mainly (91.3%) conducted among out-of-hospital cardiac arrest (OHCA) cases; others included trauma and general patients. Most of the publications were done during 2020, probably due to the increased need for emergency services as a result of the COVID-19 pandemic. The majority of studies were conducted in regions outside Africa, except a single study in Uganda.

Bystander

Forty (87%) of the articles were deemed to exhibit the combined activity of the bystander, that is, calling/activating EMS and performing cardiopulmonary resuscitation (CPR), while the remaining six articles (13%) only focused on the sole purpose of bystander of activating EMS. CPR is defined as any attempt at chest compression, with or without ventilation.[64] Another area of interest in EMS response time was casualty outcomes. Survival to the hospital is defined as a palpable carotid pulse on arrival at the hospital as documented on the patient care record [65] 83.3% of studies highlighted the association between emergency response time and higher survival rates.[12, 20-24, 27-38,40-58,61-63] Immediate bystander caller was defined as an independent predictor of survival.[45]

Emergency response time

Sampled studies reported varied PEC response times. None of the studies have comprehensive information on PEC response time that includes notification, activation, provider response, transportation, and handover intervals. Studies report combined notification, activation, and provider response mean intervals that ranged from ≤4 minutes to 20 minutes.[54] In different cases combined notification and activation mean interval is reported to range from 1 minute to 1.04 minutes.[45, 61] A different case reports a notification interval of 10.6 minutes and a combination of activation and provider response mean interval of 10.2 minutes.[50] Mean transportation interval is only documented in two studies and ranges from 16.69 minutes to 27 minutes.[54,61] None of the studies document handover interval.

Bystander and emergency response time

Bystanders activate emergency services in all the studies, and significantly reduce PEC response time in 26% of the studies,[3-10,22-29,71-75] except in two studies.[27,28] The Presence of bystander, bystander CPR and shorter notification, activation, and provider response intervals in patients is associated with high survival and good neurological outcomes.[23,31-55] Notification interval, activation interval, and provider response interval faster than 4 and 5 minutes are significantly associated with good neurological recovery and better survival to hospital discharge.[21,24] Notification interval, activation interval, and provider response interval of <8 minutes are associated with increased survival chances of OHCA patients.[23,51]

Likelihood of survival and good neurological outcomes decrease with increasing notification interval, activation interval, and provider response interval (>8 minutes). Alqudah *et al.* noted that ambulance response time (more or less than 8 minutes) to OHCA did not significantly influence the patient survival rate.[27] Alumran *et al.* reported a mean (SD) notification interval of 10.6 (13.1) minutes, and provider response interval of 10.2 (4.3) minutes where 17.9% of OHCA patients had a return of spontaneous circulation, 8.5% survived to hospital admission, and 2.0% survived to discharge.[50] Notification and activation of 1 minute, provider response intervals of 8 minutes, and transport interval of 27 minutes are associated with low survival.[54] Similarly, Ong *et al.* reported an average notification and activation interval of 1.04 minutes and an average provider response interval of 9.82 minutes. An average transportation interval of 27.55 minutes had a low overall immediate survival rate of 14.1%, and the rate of survival to hospital discharge was 1.25%.[61] Every one minute of added ambulance response time, the odds of shock-able presenting rhythm decline by 8%.[47] Decreasing ambulance response time by even a few minutes can potentially lead to many additional lives saved every year.[36] Delay in ambulance response is also reported and attributed to insufficient and inaccuracies in information, and delayed notifications by bystanders.[34] Strategies to reduce response time including leasing more ambulances, and use of toll-free numbers are recommended in 95.2% of the studies.[22-34, 35-39, 41-44, 46-66]

Improvement in survival is observed despite an average notification interval, activation interval, and provider response interval of 16.0 min in cases where patients are initially shocked using paddles by bystanders.[31] Swain *et al.* reported an inverse association between ambulance response time interval and survival following all bystander-witnessed cardiac arrests.[53]

Discussion

This systematic review analyzes the influence of bystanders on PEC response time. Bystanders mainly activate EMS by calling EOC and in some cases perform CPR. Bystanders significantly reduced PEC response time with combined notification, activation, and provider response mean intervals that ranged from ≤ 4 minutes to 20 minutes.[29-37] The Presence of bystander, bystander CPR, and bystander shorter notification, activation, and provider response intervals mostly of ≤8 minutes is associated with high survival and good neurological outcomes.[31-61] This is similar to a study by Apiratwarakul *et al.* and indicates that quick and accurate accident notification systems and accessible EMS are considered effective means to reduce the risk of death and the need for restorative care within a "golden hour" to ensure the best chances of making a full recovery.[66] Study by Ong *et al.* states that, early bystander CPR and prompt EMS care are associated with improved OHCA survival outcomes.[15] The authors report that the optimal response time threshold for survival to hospital discharge for OHCA is 6.2 min, and 4.2 min in the absence of a witness. Another study by Kobusingye *et al.* demonstrates that the response time thresholds for return of spontaneous circulation, survival to discharge, and favorable neurological outcomes are 11.5, 7.5, and 7.5 min, respectively. Bystander call to EOC also creates an opportunity for dispatcher-assisted telephone first aid or CPR which is associated with a higher survival rate and better neurological outcomes.[10] This implies that PEC response time is in most cases limited, otherwise morbidity and mortality are unavoidable consequences.

Short, combined notification and activation mean intervals are reported to range from 1 minute to 1.04 minutes,[54, 61] longer notification intervals of 10.6 minutes,[50] and combination of activation and provider response mean interval of 10.2 minutes.[30] The mean activation time is 0.57±0.22 minutes and 1.11±0.18 minutes for motor lance and ambulance, respectively in Thailand,[67] similar to

that in China of 1.68 minutes,[68] and in Iran of 2.38 minutes. Noteworthy, activation interval significantly depends on patients' level of consciousness and the mechanism of injury,[69] which is not assessed in the study. Provider response interval for motor lance and vehicle ambulance are respectively 6.12 minutes and 9.10 minutes in India,[70] 5.57±1.21 and 7.29±1.32 minutes in Thailand, 6.18 minutes in China,[63] and 10.07 minutes in Iran.[69] Response interval is slightly longer during daytime as compared to night.[67] Mean transportation interval is reported only in 2 studies, ranging from 16 minutes to 27 minutes.[54, 61] Korakot *et al.* report a longer PEC response time of 30.16 minutes.[69] A couple of factors influence notification interval, mainly the presence and ability of bystanders to call. Uncertainty analysis of accident notification time and EMS response time in work zone traffic accidents shows that the notification interval is primarily influenced by crash time road type and weather. Notification interval is longer when accidents occur during a holiday and in poor light conditions.[66] Sirikul *et al.* indicate that the only significant interval is the provider response time regardless of the hospital location, setting, and patient characteristics.[14]

None of the studies document handover interval. Similarly to other studies, there is a gap in the documentation of specific PEC response time intervals, which hinders efforts to establish the true impact of response time in saving lives. Handover is a complex process that requires the effective transfer of all required patient information in the most time-efficient manner, which could be the reason for low coverage in research.[71]

Importantly, decreasing activation, notification, and provider response time by even a few minutes can potentially lead to many additional lives saved every year.[36] As reported by Lim *et al.*, there is an 11% reduction in fatalities if the notification interval is reduced from 5.2 to 3 minutes.[37] A different study by Apiratwarakul *et al.* indicates that the mortality can be reduced by 6 percent if the notification interval is set to 1 minute.[66] Likelihood of survival and good neurological outcomes decrease with increasing notification interval, activation interval, and provider response interval (>8 minutes),[27,54,61] confirming the central role of bystanders in the immediate activation of EMS.

Delay in PEC response is attributed to insufficient and inaccuracies in information and delayed notifications by bystanders.[34] Reasons for delayed PEC response time are reported in most cases as longer during daylight and rush-hour intervals and shorter with the use of lights and sirens.[72] Strategies to reduce PEC response time including leasing more ambulances, and use of toll-free numbers are recommended in 95.2% of the 46 studies.[22-34,35-39,41-44, 46-66] Reducing PEC response time and increasing bystander CPR independently increase OHCA survival.[14,36]

Limitations

This study has some limitations. When selecting articles for a systematic review, there is at least some reviewer bias as judgment is involved in screening and selection. The effects of bias were mitigated by involving multiple reviewers, both for selection and subsequent analyses. There are undoubtedly some articles that might have been omitted which were relevant, or included which were less relevant. A further limitation is that the time frame of this study is around 21 years. While that is considerable, there are likely several articles that were published before 2000 that were not included. Finally, the study included a narrow definition of search terms, to ensure that all relevant studies were captured.

Conclusions

Besides the provision of first aid, there is evidence that emergency response time is one of the key determinants of mortality and morbidity among casualties. Immediate bystander caller is defined as a key independent predictor of survival due to the ability to activate EMS and reduce PEC response time. Bystander intervention has been identified to significantly reduce PEC response time and increase survival rates. Studies strongly recommend interventions aimed at increasing bystander support especially by activating EMS and CPR, especially in countries currently developing their EMS systems, such as Africa and Asia. Emergency response time and attributable outcomes as a field are either understudied or under-published in Africa. In addition, the lack of PEC infrastructure and monitoring systems in third-world countries could inhibit the success of studies that entail PEC response time and attributable outcomes. Moreover, a gap exists in the documentation of specific PEC response time intervals, which hinders efforts to determine the true impact of different PEC response time intervals in saving lives. Bystander empowerment through education for immediate activation of PEC services is one of the least explored areas in previous research, making it an interesting subject for future studies. Findings from our analysis of the current literature confirm and strengthen the role of PEC services in the management of time-dependent situations, in which bystanders play a central role.

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Online Supplementary Materials

Table 1. Primary data table, including the study authors, year of publication, geographic region, role of bystander, emergency response time/effect, study design, and type of casualty.