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Impact of Prehospital Response Time on Survival and Clinical Outcomes in Emergency Patients

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ABSTRACT: Prehospital response time is a critical factor influencing survival rates and clinical outcomes for patients experiencing medical emergencies. Timely intervention by

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emergency medical services (EMS) can significantly reduce morbidity and mortality, particularly in cases of cardiac arrest, trauma, and severe respiratory distress. Studies have demonstrated that shorter response times correlate with increased chances of survival and favorable post-resuscitation outcomes. For instance, quick treatment markedly improves the likelihood of restoring normal heart rhythm in cardiac arrest victims, underscoring the importance of having efficient dispatch systems and adequately trained paramedics who can deliver advanced life support on site. Beyond immediate survival, the impact of prehospital response time extends to longer-term clinical outcomes, including neurological function and health-related quality of life. Delays in EMS response can lead to complications such as irreversible organ damage, which complicates recovery and increases healthcare costs. Patient outcomes can also be influenced by factors such as the availability of specialized care, the stabilization of the patient during transfer, and the protocols followed by emergency responders. As healthcare systems strive to improve survival rates and overall patient care, optimizing prehospital response times has become a vital component of emergency medical strategies, involving coordinated efforts between different healthcare entities and investment in technology-driven solutions.

INTRODUCTION

Prehospital response time—the interval between receipt of an emergency call and arrival of emergency medical services (EMS) personnel at the scene—is the most visible performance indicator of an EMS system and the figure most often reported to the public, used in commissioning, and targeted in fleet and station planning. The intuitive rationale is straightforward: for a patient in cardiac arrest, exsanguinating haemorrhage, or acute airway compromise, every minute without definitive intervention represents lost physiological reserve, and shortening the time to professional care should therefore improve survival. However, the empirical literature shows that the relationship between response time and outcome is conditional rather than uniform. A 2025 systematic review and meta-analysis concluded that, with very low certainty of evidence, there is insufficient evidence to infer a consistent association between EMS response time and patient survival across all patient categories combined [1]. In contrast, condition-specific studies in out-of-hospital cardiac arrest (OHCA), major trauma, and acute stroke repeatedly show that delays in prehospital intervals are associated with worse outcomes, including lower survival and poorer neurological recovery [2–4]. The apparent contradiction is not a paradox; it indicates that the impact of response time depends on diagnosis, physiological state, EMS capability, geography, and the ability of the receiving hospital to deliver definitive care without further delay. This article examines the evidence linking prehospital response time to survival and clinical outcomes, identifies the conditions in which time matters most, and considers the methodological and systemic factors that shape the observed associations.

Defining and Measuring Prehospital Response Time

Before evaluating the impact of response time, it is necessary to specify what is being measured, because the term is used inconsistently in research and operational practice. The most common definition is the interval from receipt of the emergency call to arrival of the ambulance at the scene. Some agencies begin the clock at dispatch rather than call receipt, and others distinguish a "delay time" between call reception and ambulance dispatch from the response time proper [5]. The response interval is only one component of the total prehospital interval. A standard taxonomy separates delay time (call receipt to dispatch), response time (call receipt to scene arrival), on-scene time (scene arrival to departure), transport time (scene departure to hospital arrival), and total prehospital time, which sums the response, on-scene, and transport components [5,6]. This decomposition matters because interventions that shorten one interval may lengthen another. For example, a system that dispatches the nearest available unit rapidly may send a lower-capability team that then requires a longer on-scene time, whereas a system that waits for an advanced life support unit may have a longer response interval but a shorter on-scene interval [6,7]. Studies that examine only the response interval while ignoring on-scene and transport times therefore provide an incomplete picture of the time that actually elapses before definitive care is reached.

Table 1. Standard prehospital time intervals and their definitions

Interval	Definition	Principal determinants
Delay time	Receipt of emergency call to dispatch of ambulance	Call-processing efficiency, dispatch protocols [5]
Response time	Receipt of call to arrival at scene	Station location, traffic, distance, fleet availability [5,6]
On-scene time	Arrival at scene to departure from scene	Clinical complexity, interventions, extrication [7]
Transport time	Departure from scene to arrival at hospital	Distance, destination choice, traffic [6]
Total prehospital time	Sum of response, on-scene, and transport times	Integrated system performance [5–7]

Physiological Rationale for Time-Critical Intervention

The biological case for minimising prehospital delay rests on the concept of the "golden hour" and its more condition-specific derivatives. In cardiac arrest, the probability of successful defibrillation declines by approximately 7 to 10 per cent for every minute of delay from collapse to shock, and the window for favourable neurological recovery is measured in minutes rather than hours [8,9]. In major trauma, prolonged haemorrhage leads to the lethal triad of coagulopathy, hypothermia, and acidosis, and the time to surgical or endovascular haemostasis is a critical determinant of survivability [10]. In acute ischaemic stroke, approximately 1.9 million neurons are lost per minute without reperfusion, and the benefit of both intravenous thrombolysis and endovascular thrombectomy declines steeply with delay [11]. These physiological models provide the theoretical basis for time-based EMS targets, but they also explain why the strength of the response-time–outcome relationship differs by condition: in cardiac arrest and stroke, the relationship is steep and biologically immediate, whereas in many undifferentiated emergencies, the patient's condition may be stable enough that a few minutes of response delay do not materially alter outcome [1,8,11].

Out-of-Hospital Cardiac Arrest

OHCA is the emergency condition in which the effect of response time is most consistently demonstrated. Survival depends on the chain of survival: early recognition, early cardiopulmonary resuscitation (CPR), early defibrillation, advanced life support, and post-resuscitation care [2,8]. Response time influences the interval to first professional CPR and defibrillation, and registry studies have repeatedly found that shorter response intervals are associated with higher rates of return of spontaneous circulation (ROSC), survival to hospital discharge, and neurologically intact survival [2,9,12]. The effect is particularly strong when bystander CPR is absent or when the arrest is witnessed and shockable, because in these circumstances the responding EMS unit is the first effective link in the chain [12,13]. Dispatch-assisted CPR and community first-responder programmes can partially decouple survival from ambulance response time by starting chest compressions and applying automated external defibrillators before EMS arrival [13]. Nevertheless, response time remains a key modifiable system variable, and the marginal survival benefit of reducing response time is greatest in areas with long baseline intervals and low bystander intervention rates [14].

Table 2. Illustrative outcome patterns in out-of-hospital cardiac arrest according to response interval

Response interval	Typical survival to discharge	Neurological outcome	Main interpretive caveat
≤ 4 minutes	Highest in witnessed shockable arrest	Best favourable neurological survival	Confounded by bystander CPR and public AED access [2,13]
4–8 minutes	Intermediate	Moderate favourable outcome	EMS capability and on-scene time modify effect [9,12]
> 8 minutes	Lowest	Poor neurological survival	Case mix and rurality may exaggerate association [1,14]

Major Trauma

In major trauma, the relationship between response time and survival is more contested than in cardiac arrest. The traditional "golden hour" concept holds that definitive haemorrhage control within 60 minutes improves survival, and many trauma systems use response and transport times as quality indicators [3,10]. However, large observational studies have produced mixed results. A North American prospective cohort found that longer EMS intervals were associated with higher mortality in some trauma subgroups, but the association was attenuated after adjustment for injury severity, physiology, and scene factors [15]. Other work suggests that transport interval and destination choice may be more important than response interval, because the critical determinant is time to definitive haemostasis rather than time to first EMS contact [16]. Trauma system configuration—including prehospital triage, bypass of non-trauma centres, and availability of helicopter emergency medical services—can modify the effect of response time substantially [17]. Thus, response time should be interpreted as one component of a broader time-to-definitive-care pathway rather than as an isolated determinant of trauma survival.

Acute Stroke

In acute ischaemic stroke, the evidence for time-dependence is strong and biologically coherent. Intravenous thrombolysis is most effective when administered within 4.5 hours of symptom onset, and the benefit declines with every minute of delay; endovascular thrombectomy is similarly time-sensitive, with better outcomes when reperfusion is achieved early [4,11,18]. Prehospital response time contributes to the total onset-to-treatment interval, but its relative contribution varies with geography, hospital proximity, and prehospital triage pathways. Mobile stroke units and prehospital stroke scales can shorten the time to thrombolysis by enabling imaging and treatment before arrival at a comprehensive stroke centre [19]. International guidelines therefore emphasise reducing both prehospital and in-hospital delays, and they recommend regional systems that route suspected stroke patients directly to centres capable of reperfusion therapy [20]. In stroke, the response-time–outcome relationship is best understood as a continuous, steep gradient rather than a threshold effect, and even modest reductions in delay can produce measurable gains in functional independence [18,19].

Other Emergency Conditions

For many other emergency conditions, the evidence linking response time to outcome is weaker or more heterogeneous. In sepsis, early recognition and antibiotic administration are time-critical, but the prehospital interval is only one part of the pathway, and EMS response time has not been consistently associated with mortality after adjustment for illness severity [21]. In obstetric emergencies, such as postpartum haemorrhage or eclampsia, rapid transport to a facility with obstetric and surgical capability is important, but the quality of on-scene care and destination selection may matter more than the response interval itself [22]. In paediatric emergencies, response time interacts with age-specific physiology, caregiver presence, and the availability of paediatric-capable receiving facilities, making simple time–outcome associations difficult to establish [23]. These examples reinforce the general conclusion that response time is a system-level indicator whose clinical impact is mediated by condition, capability, and continuity of care.

Confounding and Methodological Challenges

The literature on response time and outcomes is affected by several methodological problems that complicate causal interpretation. First, indication bias may operate: sicker patients may be prioritised for the nearest unit, or conversely, rural and isolated patients may have longer response times and worse outcomes because of geography rather than delay itself [1,24]. Second, response time is measured inconsistently across studies, and many datasets do not distinguish call-processing time, dispatch time, and scene arrival time [5,6]. Third, important confounders—bystander CPR, public access defibrillation, EMS skill level, on-scene time, transport destination, hospital capability, and socioeconomic status—are often incompletely adjusted [7,14]. Fourth, survival is a relatively crude outcome for conditions in which functional recovery, neurological status, and time to definitive treatment are more informative [2,4]. Fifth, randomised evidence is scarce because response time cannot be ethically or practically randomised in most settings; quasi-experimental and natural-experiment designs are therefore important [24]. These limitations do not mean that response time is unimportant; rather, they mean that its effect must be estimated within condition-specific and system-specific pathways.

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System Design and Response-Time Targets

Response-time targets are widely used in EMS commissioning, but their scientific basis is uneven. Urban systems commonly target a first response within 8 minutes for life-threatening calls, while rural and remote systems use longer targets because geography makes uniform standards impractical [25]. Fixed targets can create perverse incentives: crews may rush to scene but then spend longer on scene, or systems may prioritise response-time compliance over clinical quality [6,7]. A more defensible approach is to use response time as one indicator within a balanced scorecard that also includes dispatch accuracy, bystander CPR rates, on-scene time, transport destination appropriateness, and survival with good neurological outcome [12,20,25]. Tiered response models—combining community first responders, basic life support units, advanced life support units, and helicopter emergency medical services—can improve effective coverage without requiring every unit to meet an unrealistic response-time target [13,17]. Similarly, prehospital triage and bypass protocols can reduce time to definitive care even when response time itself is unchanged [16,19].

Table 3. System-level strategies for reducing time to definitive care

Strategy	Mechanism	Conditions with strongest evidence
Dispatch-assisted CPR	Starts compression before EMS arrival	OHCA [13]
Community first responders and public AEDs	Shortens time to defibrillation	OHCA [12,13]
Tiered EMS response	Matches unit capability to need	OHCA, trauma, stroke [6,17]
Prehospital triage and bypass	Directs patients to definitive-care centres	Trauma, stroke [16,20]
Mobile stroke units	Enables prehospital imaging and thrombolysis	Acute ischaemic stroke [19]
Balanced performance scorecards	Avoids fixation on a single time target	All emergency conditions [25]

Disparities and Geographic Equity

Response time is not distributed equitably. Rural and remote populations, lower-income urban neighbourhoods, and areas with limited EMS infrastructure often experience longer response intervals and worse outcomes [14,24]. These disparities are partly attributable to distance and population density, but they also reflect station placement, fleet availability, traffic, and differential access to definitive-care hospitals [25]. Equity-oriented planning should therefore consider not only average response time but also the distribution of response times across populations and the proportion of high-acuity calls that exceed clinically meaningful thresholds [14,25]. Without such an approach, improvements in average performance may leave the most disadvantaged patients behind.

Technological and Dispatch Innovations

Technological innovations have changed the relationship between response time and outcome. Emergency call-taking systems now use structured dispatch protocols, video calling, and artificial intelligence-assisted triage to identify time-critical conditions earlier [6,13]. Drones carrying automated external defibrillators have been tested as a means of shortening time to defibrillation in OHCA, particularly in areas where ambulance access is slow [13]. Wearable devices and smartphone alerts can activate community responders before EMS arrival [12]. These innovations do not eliminate the importance of ambulance response time, but they can reduce the effective time to first life-saving intervention and thereby weaken the direct association between ambulance arrival and survival [13,19]. They also raise new questions about coordination, liability, and equity of access.

Limitations of the Evidence

The evidence base has several limitations. The 2025 systematic review found very low certainty of evidence for a consistent association between response time and survival across all patient categories, largely because of heterogeneity in definitions, outcomes, and confounding [1]. Many studies are retrospective registry analyses with incomplete adjustment for case mix and system factors [15,24]. Few studies measure the full prehospital interval, and fewer still link prehospital data to long-term

functional outcomes [7,20]. The COVID-19 pandemic and other system shocks have also shown that response times can change rapidly for reasons unrelated to clinical demand, complicating causal inference [24]. Consequently, clinicians and policymakers should avoid treating response time as a standalone causal lever and should instead evaluate it within a broader system of care.

Clinical and Policy Implications

For clinicians, the key implication is that response time should prompt condition-specific action rather than a uniform sense of urgency. In OHCA, every effort should be made to shorten time to defibrillation and high-quality CPR, including dispatch-assisted CPR and community responder activation [2,13]. In trauma and stroke, prehospital teams should prioritise destination selection and early notification of definitive-care centres, because time to definitive treatment may matter more than time to first contact [16,19]. For policymakers, response-time targets should be evidence-informed, geographically differentiated, and balanced against other quality measures [25]. Investment in dispatch systems, community responders, and hospital bypass pathways may produce greater survival gains than simply adding ambulances to meet a fixed response-time target [13,17]. Finally, performance reporting should distinguish response time from total prehospital time and should report outcomes that matter to patients, including survival with favourable neurological function [12,20].

CONCLUSION

Prehospital response time significantly impacts survival rates and clinical outcomes, particularly in out-of-hospital cardiac arrest (OHCA) and acute stroke, where time-critical benefits are evident. In major trauma, the benefits are influenced by transport time and system configuration, while in other emergencies, the impact is less clear. The findings of a 2025 systematic review indicate low certainty about the effects of response time across diverse conditions, suggesting that it should not be viewed as the sole determinant of outcomes. Instead, response time should be part of a broader time-to-definitive-care pathway, measured alongside other intervals to enhance overall system performance. Ultimately, while reducing response time can save lives in specific scenarios, improving the entire survival chain may yield more significant and equitable advantages.

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