

# A Systematic Review of the Relationship Between Ambulant Status and the Need for a Lights-and Siren Ambulance Response to Crashes

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## ABSTRACT

**Introduction:** Motor vehicle crashes (MVCs) can result in life-threatening injuries, and ambulances are therefore often dispatched at the highest priority response of lights-and-siren (L&S). However, assigning L&S ambulance response based on type of incident alone may result in over-triage, meaning that the patient's condition did not warrant L&S ambulance response. Potentially, the ambulatory status of the MVC patient at the scene (i.e., whether they can walk) could help inform the ambulance dispatch priority, given that ambulation reflects both a person's physical ability to walk and their conscious state. The objective of this systematic review is to examine published studies to determine whether ambulatory status of those involved in an MVC can predict the need for L&S ambulance response.

**Methods:** A systematic review of the literature was conducted. The following databases were searched: Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, Scopus, Cochrane Library and grey literature from inception until April 2, 2019, were searched. Studies meeting the following criteria were included: 1) comparative study; 2) patients involved directly in an MVC; 3) ambulatory status reported as an exposure; and 4) the need for L&S ambulance response reported as an outcome. Studies were assessed for risk of bias.

**Results:** The search strategy yielded 2,856 unique citations, including one study that directly addressed the review question. This study found that non-ambulation was a strong predictor of the need for L&S ambulance response (OR 0.13; 95% CI 0.07-0.24) based on field triage guidelines.

**Conclusion:** There was insufficient evidence to reach a conclusion regarding the utility of ambulatory status as an indicator of the need for L&S ambulance response. Further research in this field is required.

## INTRODUCTION

Motor vehicle crashes (MVCs) are the leading cause of injury-related death worldwide.<sup>1</sup> Due to the potential for life-threatening traumatic injuries in an MVC, many emergency ambulance dispatch systems assign the highest priority response of lights-and-siren (L&S).<sup>2</sup> However, routinely assigning L&S ambulance response for all MVCs may not be the best utilization of limited emergency medical service (EMS) resources, since it is likely to result in over-triage – i.e. a high priority ambulance response to a low acuity patient. Furthermore, L&S ambulance response poses an inherent increased risk of a traffic accident involving an ambulance.<sup>3</sup> In contrast, under-triage by dispatchers could mean that some patients do not receive the timely emergency care they require, potentially resulting in poorer patient outcomes.<sup>4</sup>

Previous research has found that factors relating to the physical force involved in a crash, such as vehicle intrusion depth and speed at time of collision, can predict the severity of patient injuries.<sup>5</sup> However, these factors may be difficult for bystanders to accurately describe to emergency ambulance dispatchers during the emergency call.<sup>6</sup> A novel dispatch criterion to identify patients who require a high priority ambulance response could be ambulatory status at the scene. Being ambulant refers to “walking or able to walk,” which depends on both the movement of the legs and the ability to coordinate balance and posture.<sup>7</sup> As the ability to walk has been used to indicate a non-urgent triage priority,<sup>8</sup> ambulation has the potential to be a diagnostic criterion for the need for L&S ambulance response.

Ambulation is seen as an important basis for triaging trauma patients in a range of settings. In mass casualty disasters, the “walking wounded” are given a non-urgent status for care,<sup>9</sup> and in emergency departments (ED), ambulatory status has been used to identify patients with minor injuries.<sup>10</sup> The similarity of these situations to MVCs (multiple trauma patients in one location) suggests that ambulatory status could help ambulance dispatchers to discriminate between patients requiring L&S response and those who do not in MVCs. However, there are situations where a patient may be walking after an MVC, but their condition is likely to still require L&S response. For example, a patient with an intracranial hemorrhage may be able to walk after an MVC, but require urgent care due to the high risk of mortality and importance of timely in-hospital treatment.<sup>11</sup> This study sought to systematically review the published evidence for whether ambulatory status can accurately inform the requirement for L&S ambulance response in MVCs.

## METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement was followed for this systematic review.<sup>12</sup> Details of the protocol were registered on PROSPERO (CRD42018097283) and can be accessed at [https://www.crd.york.ac.uk/prospero/display\\_record.php?RecordID=97283](https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=97283).

### Study question

Is the ambulatory status of those involved in an MVC associated with the need for L&S ambulance response?

### Eligibility criteria

To be included in this review, studies needed to meet four criteria: 1) the study must be a comparative study, including randomised controlled trials, cohort studies, cross-sectional studies, case-control studies; 2) study participants must be people directly involved in an MVC; 3) the study must report ambulatory status of the patient at the scene as an exposure; and 4) the study must report the need for L&S response as an outcome.

An MVC was defined in this review as a crash on a public road or highway. Vehicle types of cars, buses, trucks, motorcycles, bicycles, and scooters were included; however, larger transport types (e.g. trams and trains) were excluded. All road user types were included (such as drivers, passengers, motorcyclists, bicyclists, and pedestrians). However, crashes in which no vehicles were involved, such as a single-pedestrian incidents, were excluded.<sup>13</sup>

Ambulation was defined as walking or being able to walk.<sup>14</sup> Entrapped patients were assumed to be non-ambulant (even though sometimes patients may be able to walk if extricated). An operational definition of the need for L&S ambulance response was not pre-specified. Reviews, conference abstracts, letters, editorials, case studies, and all other commentaries were excluded. The literature search was not limited by language or publication date.

### Information sources

Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, Scopus, Cochrane Library and grey literature via Mednar from inception date up to April 2, 2019 were searched. Review articles were used to find other relevant articles, and reference lists from articles were used to identify additional sources.

### Search strategy

Our search strategy involved three key concepts: ambulation, motor vehicle crashes, and the need for L&S ambulance response (see Appendix 1). Keywords relating to these three concepts were combined with the boolean operator ‘AND.’

### Study selection

Author EC performed the database searches and conducted an initial review based on title and abstract to select potentially relevant papers. All identified studies were then independently assessed by authors EC and HT to ensure the eligibility criteria were met. Discrepancies were resolved by consensus.

### Data collection process and data items

Data items were extracted by EC onto an electronic spreadsheet relating to the year of publication, research design, sample size, the population of interest, predictor and outcome measures; and double-checked. Authors were contacted when further information was required to determine the eligibility of studies.

### Risk of bias in individual studies

Methodological quality of the studies was independently assessed by two authors (HT and EC) using the Newcastle-Ottawa Scale (NOS) for cohort studies.<sup>15</sup> This scale comprised nine items relating to the selection of the exposure and outcomes, comparability of groups, and how the outcome was assessed and followed up. Consensus about the risk of bias was reached by discussion.

### Statistical analysis and synthesis of results

Odds ratios comparing odds for the requirement of L&S ambulance response in ambulating participants to the odds in non-ambulating participants were computed. Heterogeneity between studies was assessed using the  $I^2$  statistic, with the rule that results would not be pooled if  $I^2$  exceeded 50% (high heterogeneity).<sup>16</sup> It was planned that funnel plots would be examined for potential publication bias.

## RESULTS

Our search strategy yielded 2,856 unique citations. The titles and abstracts were screened, identifying seven potentially relevant articles.<sup>17-23</sup> The full text of these articles was then reviewed for eligibility according to the inclusion criteria. One article<sup>17</sup> remained after full texts were reviewed (Fig. 1); therefore, only a narrative summary of results is provided.

### Study characteristics

The characteristics of the one included study (Isenberg et al.<sup>17</sup>) are summarised in Table 1. This was a cohort study conducted in

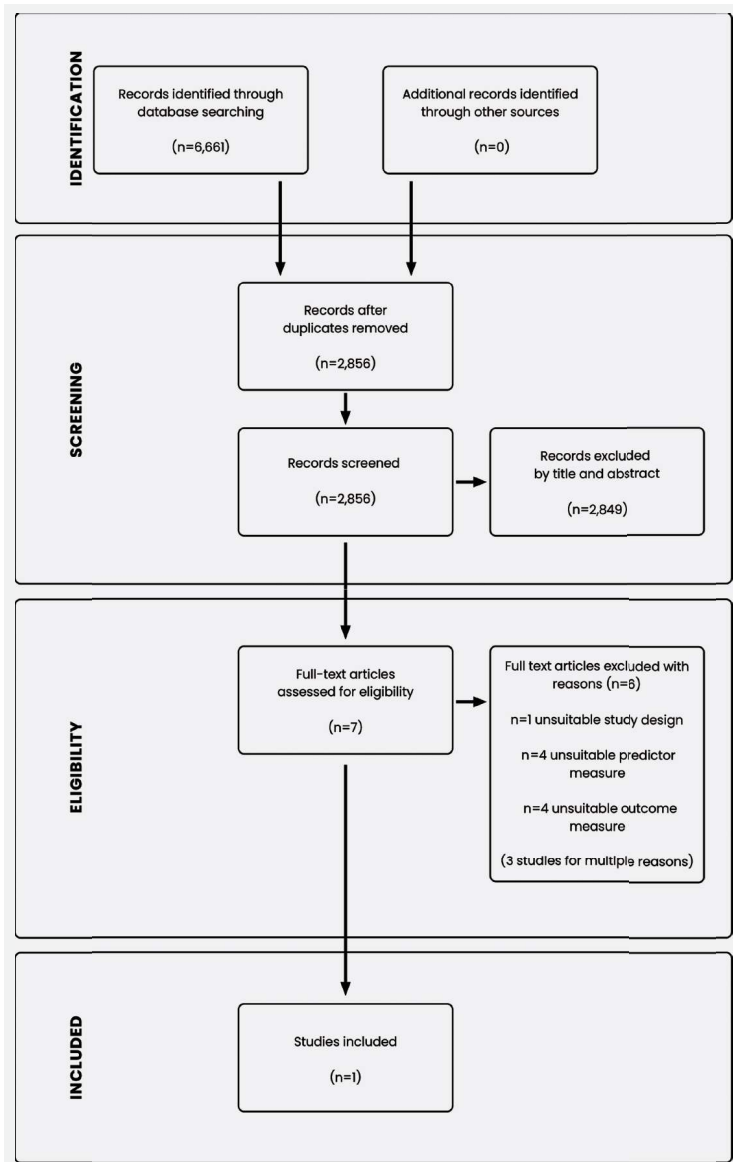


Figure 1. PRISMA flow diagram

for Field Triage of Injured Patients,”<sup>24</sup> which involved consideration of physiologic, anatomic, and mechanistic criteria. The first author of the included study was contacted to clarify how ambulatory status was determined, who confirmed that this was based on a review of each patient’s ambulance chart (D. Isenberg, personal communication, 7th June 2018).

**Methodological quality**

The study scored 7 out of a possible 9 on the Newcastle-Ottawa Scale,<sup>15</sup> and was deemed to be good quality. Points were deducted for comparability of cohort (limited information on adjustment of confounders).

**Results of individual studies**

Isenberg et al.<sup>17</sup> found that of 509 MVC patients, n=304 (60%) were ambulant at the scene; and of these 15 (4.9%) required L&S ambulance response; in comparison, of the 205 patients (40%) who were not ambulant, 58 (28.3%) required L&S response. Based on these data, there was an 87% lower odds of requiring L&S ambulance response for ambulant compared to non-ambulant MVC patients (OR 0.13; 95% CI 0.07-0.24).

**Synthesis of results**

Given that a single study met the inclusion criteria a meta-analysis was not undertaken.

**Characteristics of excluded studies**

Table 2 shows the characteristics of excluded studies. The reasons for exclusion were: unsuitable type of study design (n = 1),<sup>23</sup> unsuitable measurement of ambulatory status (n = 4)<sup>19-22</sup> and unsuitable measurement of a need for L&S response (n=4).<sup>18,20-22</sup> Three studies were excluded for multiple reasons.<sup>20-22</sup>

**DISCUSSION**

Despite ambulation being seen as an important basis for triaging trauma patients in emergency-department and mass-casualty environments,<sup>9,10</sup> there is limited evidence of its value for triaging ambulance calls for MVCs. In this systematic review, there was only one study that specifically addressed our review question and met our inclusion criteria.<sup>17</sup> Isenberg et al.<sup>17</sup> found that the ambulatory status of patients at the scene of

an MVC was a strong predictor of the need for L&S ambulance response. However, despite this strong effect size (OR=0.13), the Isenberg et al. <sup>17</sup> study indicates that using ambulatory status alone as an indicator of the L&S response in MVCs would lead to both under-triage (5% of ambulatory patients required L&S), and over-triage (72% of non-ambulatory patients did not require L&S). In relation to this, it is important to note that the optimal prediction

Study ID/ Country	Year	Study Design	Population	Age group	Total (n)	Predictor	Outcome
Isenberg et al. <sup>17</sup> USA	2012	Retrospective observational study	Motor Vehicle Crash patients transported to a Level I trauma center	All ages	509 (205 not ambulant)	Ambulation v non-ambulation	Criteria of the Guidelines for Field Triage of the Injured Patient (patient did/did not meet the criteria) <sup>24</sup>

Table 1. Characteristics of Included Study

the USA that evaluated on-scene ambulatory status related to people transported to a Level I Trauma Center who had been in an MVC. Isenberg et al. <sup>17</sup> attempted to identify MVC characteristics (including ambulatory status) that could easily be identified by emergency callers and were associated with the need for an ambulance L&S response. Isenberg et al.<sup>17</sup> defined the need for L&S ambulance response according to the published “Guidelines

Study ID/Country	Year	Primary Reason for Exclusion
Loza <sup>23</sup> /USA	2013	Conference abstract.
McCoy <sup>18</sup>	2017	Outcome measure (Glasgow Coma Scale score and spinal injury) did not adequately represent the need for a lights & sirens response.
Merlin <sup>19</sup> /USA	2013	No comparison group for ambulation.
Ryb <sup>21</sup> /USA	2011	Ambulatory status of patients was not clearly defined. The authors compared characteristics among those ejected, self-exited, exited with assistance, removed from the vehicle with decreased mental status, removed due to perceived serious injury and removed for other reasons. A large proportion of patients (25%) had unknown mobility. The outcome measure was also not adequately reported.
Ryb <sup>20</sup> /USA	2011	Ambulatory status not clearly defined. The authors used scene mobility information as follows: ejection, removed due to decreased mental status, self-exited, exited with assistance, removed due to perceived serious injury. Outcome measure not adequate (ISS>15).
Scheetz <sup>22</sup> /USA	2007	Ambulatory status of patients was not clearly defined. The authors compared the characteristics of those fatal when removed, unconscious/disorientated, serious injury, exit own way, exit some assist, ejected. Outcome measure not adequate (ISS>15).

**Table 2.** Characteristics of Excluded Studies

model developed by the authors of this paper (Isenberg et al.<sup>17</sup>) used ambulation in combination with two other variables (whether the MVC was on an interstate road/highway; whether the MVC involved more than one car). Thus, the limited evidence to date suggests that while ambulation is a strong predictor of the need for L&S response in MVCs, its value as a predictor may require that it is used in combination with other predictors.

Systematic reviews finding few papers serve an important purpose in identifying research gaps.<sup>25,26</sup> Higgins and Green eloquently distinguish between “evidence of no effect” and “no evidence of effect,”<sup>27</sup> and it is the latter that is relevant here. Systematic reviews that find few papers with strong effect provide valuable information to researchers and funding institutions regarding gaps in knowledge and directions for research.<sup>28</sup> It is suggested that future research should be undertaken in this field.

A study of Cochrane Systematic Reviews proposed three reasons for a systematic review finding few or no papers, namely: the area of study is relatively new and can be considered immature; the study question was narrow in focus, or the criteria for inclusion/exclusion were overly restrictive.<sup>25</sup> However, in our review one reason for exclusion of studies was the predictor variable of interest was not sufficiently specific to identify if people were ambulant after a crash. Two of the excluded studies<sup>21,22</sup> used data derived from the National Automotive Sampling System Crashworthiness Data System (NASS-CDS). The NASS-CDS collects information on a representative sample of police-reported MVCs in the United States. This system records “occupant mobility status,” which on face value appears to be a measure of ambulatory status; however, a closer inspection of the variable revealed it was unsuitable. “Occupant mobility status” classifies people according to how they exited their vehicle after a crash, with categories of ejected, self-exited, exited with assistance, removed from the vehicle with decreased mental status, removed due to perceived serious injury or removed for other reasons.<sup>29</sup> The categories do not necessarily indicate ambulatory status. For example, a patient could self-exit

a vehicle, but not be ambulant after this action. Data from the NASS-CSC is therefore unsuitable for this kind of study.

Although there was only one study that met the inclusion criteria for our review, there have been other papers published that have considered using ambulatory status for ambulance dispatch triage in MVCs.<sup>30</sup> For example, a descriptive (non-comparative) study which did not meet our inclusion criteria due to study design concluded that ambulatory status could not be reliably used to triage patients after an MVC, as some patients who were ambulant also had serious injuries or required hospitalization.<sup>19</sup> A further

study by McCoy et al.<sup>18</sup> reported that non-ambulant patients were more likely to have reduced GCS scores or be at risk of spinal injury than ambulant patients. However, it was determined that while these outcomes measures are suggestive of the need for L&S response, they were not sufficient to determine this outcome.

**Limitations**

Despite searching for grey literature, a limitation of this study could be the non-identification of unpublished literature. Publication bias or the “file drawer effect” is thought to occur with the favoring of positive results for publication.<sup>31</sup> It is possible that research concluding that ambulation was not a suitable triage criterion have systematically been excluded from publication and resulted in the findings here. However, with only one study identified, the potential for publication bias through a funnel plot could not be assessed.

**CONCLUSION**

A single study identified in this systematic review suggests that ambulatory status has the potential to be a useful criterion to identify patients who require a lights-and-siren ambulance response at the scene of an MVC. However, this study also indicates that using ambulatory status alone would lead to high rates of under-triage and over-triage, and that it may be necessary to use ambulatory status in combination with other predictors. The key finding of this paper is the gap in existing literature and therefore it is hoped that these findings will stimulate research in this field. Methodological considerations for future research could include improved identification of the ambulatory status of patients and accurate measurement of those requiring a lights-and-siren ambulance response.

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#	Medline terms	Results (n)
1	(road OR traffic OR motor\$ OR vehicle OR MVA OR MBA OR driver OR passenger OR pedestrian OR scooter OR bicyc\$ OR cyclist OR truck ) AND (crash OR accident) .mp.	21,246
2	accidents, traffic.sh OR automobile driving.sh,xm OR motor vehicles.sh,xm OR automobile driving.sh OR bicycling.sh OR pedestrian.sh	64,584
3	1 or 2	71,782
4	(triage OR over?triage OR under?triage OR urgen* OR acuity OR patient condition OR injury OR Glasgow coma score OR GCS OR abbreviated injury score OR AIS OR injury severity score OR ISS OR survival risk ratio OR severity OR SRR OR light?*siren? OR L&S OR dispatch or ambulance or emergency or severe).mp.	2,275,409
5	triage.sh. OR wounds and injuries.sh,xm. OR health status indicators.sh,xm. OR critical care.sh. OR patient acuity.sh OR injury severity score.sh or "severity of illness index".sh OR trauma severity indices.sh OR ambulatory care.sh,xm. OR ambulances.sh. OR emergency medical services.sh,xm. OR emergency medical technicians.sh.	507,642
6	4 or 5	2,400,033
7	(ambulat* or ambulant or walk* or self?extricat* or mobil*).mp.	582,736
8	walking.sh, OR ambulation.sh,	29,693
9	7 or 8	582,736
10	3 and 6 and 9	1,354
11	rehabilitation.sh	19,312
12	10 not 11	1,342

**Appendix 1.** Search strategy (Medline)