

Association Between Emergency Medical Service Response Time and Motor Vehicle Crash Mortality in the United States

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IMPORTANCE Motor vehicle crashes (MVCs) are a leading public health concern. Emergency medical service (EMS) response time is a modifiable, system-level factor with the potential to influence trauma patient survival. The relationship between EMS response time and MVC mortality is unknown.

OBJECTIVES To measure the association between EMS response times and MVC mortality at the population level across US counties.

DESIGN, SETTING, AND STUDY POPULATION This population-based study included MVC-related deaths in 2268 US counties, representing an estimated population of 239 464 121 people, from January 1, 2013, through December 31, 2015. Data were analyzed from October 1, 2017, through April 30, 2018.

EXPOSURE The median EMS response time to MVCs within each county (county response time), derived from data collected by the National Emergency Medical Service Information System.

MAIN OUTCOMES AND MEASURES The county rate of MVC-related death, calculated using crash fatality data recorded in the Fatality Analysis Reporting System of the National Highway Traffic Safety Administration.

RESULTS During the study period, 2 214 480 ambulance responses to MVCs were identified (median, 229 responses per county [interquartile range (IQR), 73-697 responses per county]) in 2268 US counties. The median county response time was 9 minutes (IQR, 7-11) minutes. Longer response times were significantly associated with higher rates of MVC mortality (≥ 12 vs < 7 minutes; mortality rate ratio, 1.46; 95% CI, 1.32-1.61) after adjusting for measures of rurality, on-scene and transport times, access to trauma resources, and traffic safety laws. This finding was consistent in both rural/wilderness and urban/suburban settings, where a significant proportion of MVC fatalities (population attributable fraction: rural/wilderness, 9.9%; urban/suburban, 14.1%) were associated with prolonged response times (defined by the median value, ≥ 10 minutes and ≥ 7 minutes, respectively).

CONCLUSIONS AND RELEVANCE Among 2268 US counties, longer EMS response times were associated with higher rates of MVC mortality. A significant proportion of MVC-related deaths were associated with prolonged response times in both rural/wilderness and urban/suburban settings. These findings suggest that trauma system-level efforts to address regional disparities in MVC mortality should evaluate EMS response times as a potential contributor.

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← Invited Commentary page 293

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Motor vehicle crashes (MVCs) are a leading cause of death and injury in the United States.¹ Improvements to road infrastructure, vehicle design, and traffic safety legislation have led to a decrease in crash mortality from 15.9 per 100 000 person-years in 1995 to 10.9 per 100 000 person-years in 2015.² The implementation of organized trauma systems has further reduced deaths by ensuring that patients with severe injury receive timely access to trauma care.^{3,4} However, significant variation in crash mortality persists, with rates varying by an order of magnitude between states from 3 to 25 deaths per 100 000 person-years.⁵ The contributing role of modifiable trauma system-level factors in this disparity is unclear.

Emergency medical service (EMS) response time, defined as time elapsed between EMS notification and arrival on scene, is a system-level factor with potential to influence survival. Emergency medical services provide the critical link between injury and definitive care.⁶ Early arrival of EMS at the crash scene allows for stabilization of occupants with life-threatening injuries, timely triage, and transport to hospital.^{6,7} Conversely, delays could lead to a greater risk of death.

We postulated that a relationship exists between regional EMS response capabilities and crash mortality and that reducing the time to first medical contact in the field might decrease deaths due to road traffic injuries at the system level. Therefore, we measured the association between EMS response times and MVC mortality at the population level across US counties and estimated the number of fatalities that might be prevented if response times were shortened.

Methods

Study Design

This study was a population-based analysis of MVC-related deaths within US counties from January 1, 2013, through December 31, 2015. The specific study objectives were to (1) to measure the association between EMS response time and MVC mortality at the US county level and (2) estimate the proportion of MVC-related deaths associated with prolonged response times. Data were analyzed from October 1, 2017, through April 30, 2018. This project was approved by the Sunnybrook Health Sciences Center research ethics board (Toronto, Ontario, Canada). The data sources used are publicly available and deidentified; informed consent was waived.

Data Sources

Emergency Medical Service Response Time

Data related to ground EMS activations during calendar years 2013 through 2015 were provided by the National Emergency Medical Services Information System (NEMSIS),⁸ a federally funded project designed to standardize EMS patient care reporting and facilitate collection of data for assessment of EMS systems of care.⁹ As of 2015, NEMSIS collected data related to EMS activations performed by EMS agencies in 2497 of 3144 US counties and county equivalents. We included all ground ambulance responses for possible injury due to MVCs (Figure 1). Emergency medical service response times were aggregated

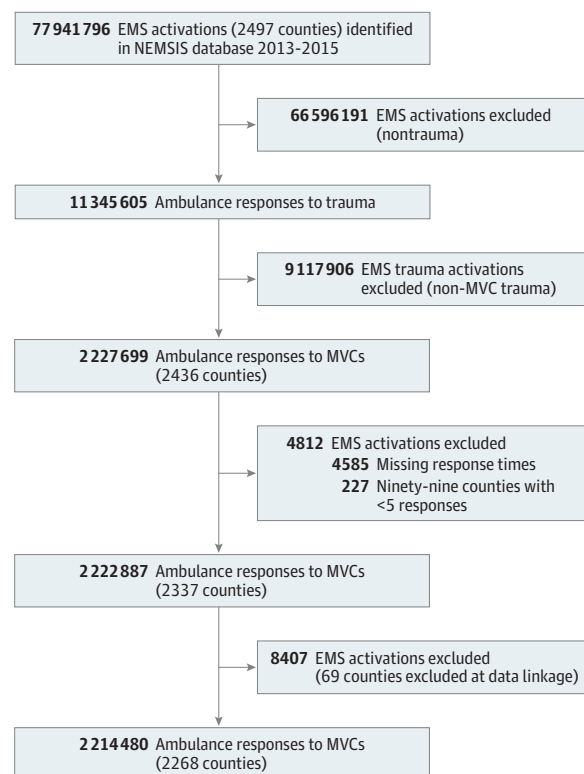
Key Points

Question Are regional emergency medical service response time capabilities associated with motor vehicle crash mortality?

Findings In this population-based study of 2268 US counties, longer emergency medical service response times were associated with higher rates of motor vehicle crash mortality after adjusting for measures of rurality, emergency medical service on-scene and transport times, access to trauma resources, and traffic safety laws. With use of the population attributable fraction, a significant proportion of motor vehicle crash deaths were found to be associated with prolonged response times in rural/wilderness and urban/suburban settings.

Meaning The findings suggest that trauma system-level efforts to address regional disparities in motor vehicle crash mortality should evaluate emergency medical service response times as a potential contributor.

Figure 1. Flowchart of Emergency Medical Service (EMS) Activations and Counties Included in the Study



MVC indicates motor vehicle crash; NEMSIS, National Emergency Medical Services Information System.

at the county level. The exposure was defined as the county median EMS response time (henceforth referred to as county response time), an ecologic measure of regional EMS responsiveness to traffic crashes. Emergency medical service activations with missing response time were excluded (<0.2%). Counties with fewer than 5 EMS responses to MVCs across the 3-year study period were also excluded (4%).

Motor Vehicle Crash Mortality Rate

Motor vehicle crash-related deaths were derived from the Fatality Analysis Reporting System of the National Highway Traffic Safety Administration.¹⁰ The Fatality Analysis Reporting System is a population-based registry that collects data related to all MVCs on public roads in the United States that result in at least 1 fatality within 30 days.¹¹ To reduce the potential for confounding, fatalities were limited to occupants of passenger vehicles. Crashes involving heavy trucks, motorcycles, off-road vehicles, cyclists, or pedestrians were excluded. The US Census Bureau provided intercensal population estimates for each county and year.¹² The primary outcome was the county rate of MVC mortality reported as deaths per 100 000 person-years. To account for demographic differences known to be associated with risk of MVC death,^{13,14} county mortality rates were stratified by age (<15, 15-34, 35-64, and ≥65 years) and sex.

Linkage of Emergency Medical Service and Motor Vehicle Crash Mortality Data

The NEMSIS Technical Assistance Center performed linkage of crash mortality and EMS data at the county level using Federal Information Processing Standards (FIPS) codes. County FIPS codes were then replaced using a random identifier to preserve anonymity. Counties where identifiable combinations of data might pose a risk to anonymity were excluded (<3% of counties). The stepwise derivation and structure of the final analytic data set is described in the eMethods in the Supplement.

Potential Confounders

We considered several factors in addition to population age and sex that might confound the association between EMS response time and MVC mortality. County rurality was estimated using county population density and rural-urban continuum codes.¹⁵ Population densities were calculated using US census population estimates¹² and grouped into quartiles (<16, 17-42, 43-108, and ≥109 persons/mile²). Rural-urban continuum codes were used to group counties into 4 categories of rurality (urban, suburban, rural, and wilderness) based on population and proximity to metropolitan areas (eTable 1 in the Supplement).

Emergency medical services on-scene and transport times to hospital might also be associated with crash mortality. These time intervals were derived for ambulance responses for which the final destination was a hospital. Median on-scene and transport times were calculated for each county.

Regional differences in EMS response time are also likely to be correlated with access to trauma resources.¹⁶ We accounted for the proximity of trauma centers¹⁷ and helicopter EMS^{18,19} to county populations. American College of Surgeons-verified and state-designated level I and II trauma centers were identified from the American College of Surgeons²⁰ and American Trauma Society²¹ databases and geocoded by address using geographic information system (GIS) software. Counties were then categorized by trauma center proximity (within county, adjacent county, or no proximate trauma center) (eFigure 1 in the Supplement).

Access to helicopter EMS was estimated for each county as the proportion of the population within 25-mile flight circles of a helicopter EMS base (corresponding to areas within 15- to 20-minute helicopter EMS response times^{22,23}) (eFigure 2 in the Supplement). Helicopter EMS bases were identified in the Atlas & Database of Air Medical Services²⁴ and geocoded by zip code. The geographic distribution of populations within counties were geocoded using the centroids of census blocks provided by the US Census Bureau.²⁵

Finally, state traffic safety laws known to influence the risk of MVC fatality were considered. These laws included the maximum posted speed limits on urban and rural highways and interstates,^{26,27} primary enforcement of seat belt laws,^{28,29} administrative license revocation for alcohol-impaired driving,^{30,31} and legislation prohibiting texting while driving.³² Traffic safety laws were obtained from the Insurance Institute for Highway Safety³³ and the Governors Highway Safety Administration.³⁴

Statistical Analysis

To assess the generalizability of our results, characteristics of counties included in the study were compared with those of excluded counties. Univariable analyses compared county characteristics across quartiles of county response time. The Wilcoxon rank sum and Kruskal-Wallis tests were used in analysis of continuous variables, and frequencies were compared using the χ^2 test.

A hierarchical negative binomial regression model was used to estimate the risk-adjusted association between county response time and MVC mortality. This model was a generalized linear mixed model with random effects to account for clustering of counties within states.

To estimate the proportion of MVC-related deaths associated with prolonged EMS response times, we used the population attributable fraction.³⁵⁻³⁷ The population attributable fraction is defined as the fraction of all cases (in this case, MVC fatalities) in a population that is attributable to a specific exposure (in this case, prolonged response times), assuming a causal relationship. This was estimated using adjusted mortality rate ratios (MRRs) from the hierarchical model using the formula described by Rockhill et al³⁷ and Miettinen³⁸: population attributable fraction = $P_c (1 - 1/MRR) \times 100\%$, where P_c is the proportion of MVC fatalities that occurred in counties with prolonged response times (prevalence of the exposure among cases). In this study, the population attributable fraction can be interpreted as the estimated fraction of all MVC fatalities that might have been prevented if all counties achieved response times below the defined threshold.

Owing to geographic and resource constraints, it is unlikely that rural counties would be able to achieve EMS response times comparable to those of urban counties. Therefore, we performed a stratified analysis grouping counties into rural/wilderness and urban/suburban counties using rural-urban continuum codes. The median county response time was calculated separately for rural/wilderness and urban/suburban counties to define the prolonged response time threshold appropriate to each context. The population attrib-

Table 1. Comparison of County Characteristics Across Quartiles of EMS Response Time^a

Characteristic	Median EMS Response Time				P Value
	<7 min (n = 480)	7-8 min (n = 629)	9-11 min (n = 656)	≥12 min (n = 503)	
County Rurality					
Rural-urban continuum					
Urban	292 (60.8)	321 (51.0)	183 (27.9)	90 (17.9)	<.001
Suburban	68 (14.2)	84 (13.4)	55 (8.4)	23 (4.6)	
Rural	102 (21.3)	179 (28.5)	293 (44.7)	156 (31.0)	
Wilderness	18 (3.8)	45 (7.2)	125 (19.1)	234 (46.5)	
Population density, people/mile ²					
<16	31 (6.5)	53 (8.4)	158 (24.1)	278 (55.3)	<.001
17-42	67 (14.0)	136 (21.6)	236 (36.0)	136 (27.0)	
43-08	117 (24.4)	174 (27.7)	191 (29.1)	68 (13.5)	
≥109	265 (55.2)	266 (42.3)	71 (10.8)	21 (4.2)	
EMS Time Intervals, Median (IQR), min					
On-scene time	16 (14-17)	17 (15-19)	17 (15-20)	19 (16-22)	<.001
Transport time	11 (9-14)	13 (11-18)	17 (13-22)	23 (15-32)	<.001
Measures of Access to Definitive Care					
Proximity to level I or II trauma center					
Within county	132 (27.5)	95 (15.1)	17 (2.6)	28 (5.6)	<.001
Adjacent county	160 (33.3)	259 (41.2)	252 (38.4)	154 (30.6)	
No proximate trauma center	188 (39.2)	275 (43.7)	387 (59.0)	321 (63.8)	
Population ≤25 miles from HEMS base, median (IQR), %	97 (37-100)	85 (20-100)	52 (1-93)	13 (0-71)	<.001
State Traffic Safety Laws					
Maximum speed limit >65 mph					
Urban highways and interstates	180 (37.5)	288 (45.8)	289 (44.1)	230 (45.7)	.02
Rural highways and interstates	409 (85.2)	556 (88.4)	599 (91.3)	460 (91.5)	.003
Primary enforcement of seat belt laws	373 (77.7)	482 (76.6)	460 (70.1)	260 (51.7)	<.001
Administrative license suspension	407 (84.8)	521 (82.8)	553 (84.3)	403 (80.1)	.18
Text messaging ban	436 (90.8)	560 (89.0)	576 (87.8)	400 (79.5)	<.001
Population and MVC Mortality					
Estimated population ^b	123 029 515	77 014 040	24 786 836	14 633 730	NA
MVC-related deaths ^b	6031	5233	3097	1737	NA
MVC mortality rate, deaths/100 000 person-years	4.9	6.8	12.5	11.9	NA
Crude mortality rate ratio, 95% CI ^c	1 [Reference]	1.27 (1.12-1.44)	1.63 (1.45-1.84)	1.95 (1.72-2.22)	<.001

Abbreviations: EMS, emergency medical service; HEMS, helicopter emergency medical service; IQR, interquartile range; MVC, motor vehicle crash; NA, not applicable.

^a Data are presented as number (percentage) of counties unless otherwise indicated.

^b Population estimates and MVC-related deaths shown are from the most recent study year (2015).

^c Estimated using empty negative binomial model.

utable fraction was then estimated for rural/wilderness and urban/suburban counties using these benchmarks.

Geospatial analyses deriving variables for proximity of trauma centers and helicopter EMS to county populations were performed using Esri ArcMap GIS software, version 10.5 (Esri). Statistical analyses were performed using SAS software, version 9.4 (SAS Institute Inc).

Results

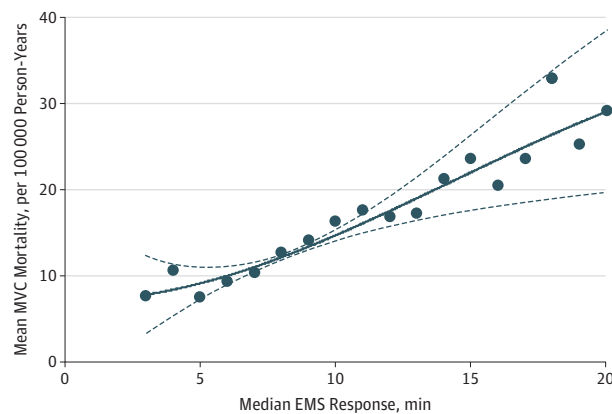
During 2013 through 2015, there were 77 941 796 EMS activations in 2497 US counties (Figure 1). We identified 2 214 480 ambulance responses to MVCs that met inclusion criteria in 2268 counties (72% of all US counties). The median number of ambulance responses to MVCs for each county was 229 responses (interquartile range [IQR], 73-697 responses).

Counties included were from 49 US states (including the District of Columbia) and accounted for an estimated 239 464 121 persons (75% of the total US population). Densely populated urban areas with greater access to trauma center care were overrepresented among the counties analyzed (eTable 2 in the Supplement).

Table 1 compares the characteristics of counties across quartiles of county response time. The median county response time was 9 minutes (IQR, 7-11 minutes). Counties with longer response times were more often rural, had longer on-scene and transport times, had less access to level I or II trauma centers, and had lower helicopter EMS availability. Conversely, counties with shorter response times were associated with greater presence of protective state traffic safety laws.

The MVC mortality rate was significantly higher in counties with longer response times. In counties with response times of 12 minutes or greater, the mortality rate was 11.9 per 100 000

Figure 2. Crude Association Between County Median Emergency Medical Service (EMS) Response Time and County Rate of Motor Vehicle Crash (MVC) Mortality



Blue circles represent the mean county MVC mortality rate associated with each incremental increase in county response time. Lines represent the best-fit polynomial to mean MVC mortality rates (solid line) and 95% CIs (dashed lines) associated with increasing county response times.

person-years; counties with response times of less than 7 minutes had a mortality rate of 4.9 per 100 000 person-years (unadjusted MRR, 1.95; 95% CI, 1.72-2.22). A near-linear association was observed between county response time and MVC mortality rate (Figure 2).

Hierarchical Negative Binomial Model

Table 2 shows the results of our hierarchical negative binomial model for county MVC mortality. After adjusting for potential confounders, longer county response times were associated with higher rates of MVC-related death (county response time, ≥ 12 vs < 7 minutes; MRR, 1.46; 95% CI, 1.32-1.61). Crash mortality was highest among males aged 15 to 34 years and in rural counties with low population density. The presence of a level I or II trauma center within a county was associated with lower mortality (MRR, 0.65; 95% CI, 0.59-0.72), whereas higher maximum speed limits on rural highways and interstates were associated with greater mortality. On-scene times, transport times, access to helicopter EMS, and other traffic safety laws were not significantly associated with MVC mortality.

MVC Deaths Associated With Prolonged EMS Response Times

We estimated the population attributable fraction of MVC deaths associated with prolonged response times in rural/wilderness and urban/suburban counties (eTable 3 in the Supplement). The median county response time among rural/wilderness counties was 10 minutes (IQR, 8-12 minutes) compared with 7 minutes (IQR, 6-9 minutes) among urban/suburban counties. In rural/wilderness counties, the proportion of crash fatalities associated with EMS response times of 10 minutes or longer was 9.9% (95% CI, 4.8%-14.1%), representing approximately 333 of 3363 passenger vehicle deaths. In urban or suburban counties, the proportion of crash fatalities as-

Table 2. Hierarchical Negative Binomial Model for County MVC Mortality

Parameter	Mortality Rate Ratio (95% CI)	P Value
County EMS Response Time		
Median EMS response time, min		
<7	1 [Reference]	<.001
7-8	1.24 (1.15-1.34)	
9-11	1.33 (1.23-1.44)	
≥ 12	1.46 (1.32-1.61)	
Population Demographic Group		
Male sex		
	1.59 (1.52-1.6)	<.001
Age, y		
<15	1 [Reference]	<.001
15-34	7.39 (6.88-7.94)	
35-64	4.39 (4.08-4.71)	
≥ 65	5.71 (5.31-6.14)	
County Rurality		
Rural-urban continuum		
Urban	1 [Reference]	.002
Suburban	1.03 (0.94-1.13)	
Rural	1.18 (1.09-1.27)	
Wilderness	1.26 (1.14-1.40)	
Population density, people/mile ²		
<16	1.90 (1.66-2.18)	<.001
17-42	1.46 (1.32-1.62)	
43-108	1.34 (1.23-1.45)	
≥ 109	1 [Reference]	
EMS Time Intervals		
On-scene time (per 2-min increase)	1.01 (1.00-1.02)	.23
Transport time (per 5-min increase)	1.01 (0.99-1.02)	.27
Measures of Access to Care		
Proximity to level I or II trauma center		
Within county	0.65 (0.59-0.72)	<.001
Adjacent county	0.98 (0.92-1.04)	
No proximate trauma center	1 [Reference]	
Population ≤ 25 miles of HEMS base (per 10% increase)	1.00 (1.00-1.01)	.27
Traffic Safety Laws		
Maximum speed limit > 65 mph		
Urban highways and interstates	1.12 (0.96-1.32)	.14
Rural highways and interstates	1.69 (1.32-2.15)	<.001
Primary enforcement of seat belt laws	0.88 (0.76-1.02)	.09
Administrative license suspension	0.86 (0.68-1.08)	.20
Text messaging ban	0.99 (0.84-1.16)	.91

Abbreviations: EMS, emergency medical service; HEMS, helicopter emergency medical service; MVC, motor vehicle crash.

sociated with EMS response times of 7 minutes or longer was 14.1% (95% CI, 11.5%-16.4%), representing approximately 1796 of 12 735 passenger vehicle deaths. Taken together, an estimated 2129 passenger vehicle deaths per year (13.2% of all crash fatalities within the 2268 counties evaluated) might have been prevented if county response times were shorter than the specified benchmarks in rural/wilderness (10 minutes) and urban/suburban (7 minutes) areas.

Discussion

In this population-based analysis of 2268 US counties, longer EMS response times were associated with higher rates of MVC mortality after accounting for measures of rurality, on-scene and transport times, access to trauma resources, and traffic safety laws. This finding was consistent in both rural/wilderness and urban/suburban settings, where a significant proportion of crash fatalities (9.9% and 14.1%, respectively) were associated with prolonged county response times.

These data have important implications for trauma system design and health policy because they suggest that efforts to address regional disparities in MVC mortality should evaluate EMS response times as a potential contributor. That ensuring short EMS response times could save lives seems intuitive. Severe trauma is a time-dependent condition. Prompt arrival of first responders at the scene of a crash provides the greatest opportunity for early stabilization of occupants with life-threatening injuries, timely triage, and mobilization of the broader trauma system to achieve disposition to definitive trauma care.⁷ Conversely, delays may confer a greater risk of death among those in need of urgent medical attention. Thus, regional systems in which delays are more common would exhibit higher rates of crash mortality after accounting for other regional differences.

It is important to place the results of this study in context with the current debate surrounding use of response time as an EMS performance measure. To date, there has been scarce evidence that response times influence trauma-related mortality.³⁹ Studies that previously examined response time intervals were hindered by a lack of risk adjustment^{40,41} or were not designed to make system-level recommendations.⁴² Furthermore, a greater emphasis on speed has the potential to put the safety of first responders at risk.⁷ For these reasons, opinion has moved away from the use of response time standards as performance indicators.

The present study adds to this discussion by showing, for the first time to our knowledge, that EMS response times may be associated with outcomes at the regional trauma-system level. These findings do not necessarily imply that EMS should simply drive faster, but rather that trauma systems should be organized to achieve a quick response to MVCs. Approaches to shortening response time intervals include ensuring adequate numbers⁴³ and optimizing the distribution of first-responding units in a dynamic and predictive fashion.⁴⁴ In regions where geographic and resource constraints are especially limiting, improvements to on-board telematics systems that predict the risk of severe injury may serve to better triage deployment.⁴⁵ Although these approaches can be costly, our results suggest that such strategies may yield a public health benefit, particularly where delays in EMS response are common. Studies of cost-effectiveness are required in this area.

On-scene and transport times were not significantly associated with crash mortality. This observation is notable because counties with longer EMS response times also had lon-

ger on-scene and transport times, reflecting differences in crash characteristics, EMS practices, and greater travel distances in rural areas. The finding that only EMS response times were significantly associated with mortality after accounting for other regional differences suggests that early medical contact with prehospital personnel is uniquely important to MVC occupant survival at the trauma-system level. Further research is needed to clarify what additional EMS structures and processes of care, such as the level of first-responding unit, provider training, or prehospital interventions, might contribute to the observed mortality benefit of early EMS arrival.

Greater access to trauma center care was associated with lower MVC mortality. Counties with level I or II trauma centers had crash mortality rates 35% lower than those with no nearby trauma center, providing further evidence that trauma centers are associated with reduced risk of injury-related death.^{17,46} Conversely, state laws allowing higher speed limits were associated with greater mortality, reaffirming the dominant role of speed in the epidemiology of fatal road traffic crashes.^{26,27}

Contrary to previous reports,^{4,28-31} primary enforcement of seat belt and administrative license revocation laws were not significantly associated with MVC mortality. These findings likely reflect the updated era in which the data were derived. During 2013 through 2015, seat belt use in the United States surpassed 86%⁴⁷ and all states had enforced the blood alcohol content limit of 0.08%.³³ Therefore, although seat belt and alcohol-impaired driving laws prevent traffic deaths, the measurable effect is likely diminished compared with previous periods.

Limitations

This study has several important limitations. First, there is potential for residual confounding due to regional differences in road traffic crash characteristics. Crash characteristics might confound the relationship between EMS response time and mortality if vehicle occupants in counties with longer response times are more likely to experience forces leading to greater injury severity. As a consequence, a greater proportion of on-scene deaths (including those not modifiable by post-crash interventions) would be observed in regions with longer response times. However, we accounted for several variables that are correlated with crash characteristics, including measures of rurality,⁴⁸ on-scene time (prolonged with extrication),⁴⁹ and traffic safety laws (particularly those related to speed). Confounding attributable to other processes of care, such as EMS notification, the quality of medical care delivered, and patterns of interfacility transfer, was also mitigated through adjustment for rurality and regional differences in access to trauma resources (trauma centers and helicopter EMS). Second, the 2268 of 3144 US counties included in our analyses were overrepresentative of densely populated urban areas with greater access to trauma center care. However, that a substantial majority of US counties (and population) were included, representing the full spectrum of rurality and resources, is a compensating strength of the study. Third, it is difficult to confirm the completeness of the EMS activations collected by NEMSIS. However,

NEMSIS captured an average of 26 million EMS activations annually during the study period (74% of an estimated 35 million nationally⁵⁰). Therefore, it is reasonable to infer that the data from which our exposure variable was derived were comprehensive for the 72% of US counties included. Finally, the exposure variable itself (median EMS response time) was an ecologic measure of regional EMS response capabilities. Therefore, caution should be taken in making inferences at the individual level from our results (ecologic fallacy).⁵¹ However, individual-level effects were not a concern within the stated objectives of the study, which were to ascertain county-level effects relevant to trauma system design and broader health policy.

Conclusions

Among 2268 US counties, longer EMS response times were associated with higher rates of MVC mortality. A significant proportion of MVC-related deaths were associated with prolonged response times in both rural/wilderness and urban/suburban settings. These findings suggest that trauma system-level efforts to address regional disparities in MVC mortality should evaluate EMS response time as a potential contributor. Further work is needed to identify other prehospital structures and processes of care that might contribute to regional disparities in trauma outcomes.

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Author Contributions: Dr Byrne had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Concept and design: Byrne, Nathens.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Byrne, Nathens.

Critical revision of the manuscript for important intellectual content: Mann, Dai, Mason, Karanicolas, Rizoli.

Statistical analysis: Byrne, Mann, Dai, Mason.

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Invited Commentary

Rapid Emergency Medical Services Response Saves Lives of Persons Injured in Motor Vehicle Crashes

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In this issue of *JAMA Surgery*, Byrne et al¹ describe their analysis of the association between emergency medical service (EMS) response time and motor vehicle crash (MVC) mortality using US county-level data. The study used information from the National EMS Information System related to ground EMS activations from 2013 through 2015. These data were linked to fatalities reported to the Fatality Analysis Reporting System of the National Highway Traffic Safety Administration. The methods were robust, with well-defined inclusion and exclusion criteria and adjustment for important covariates, such as on-scene EMS times, EMS transport times, proximity of trauma

centers, traffic safety laws, rural or urban setting, and availability of helicopter or air medical transport.

The authors analyzed records for more than 2 million ambulance responses to MVCs during the study period. They found that counties with longer response times had significantly higher MVC mortality rates (mortality rate ratio, 1.46; 95% CI, 1.32-1.61). This was true in both rural and urban areas.

Although longer response times were associated with longer transport times, which makes sense intuitively, transport times were not significantly associated with mortality. The authors' findings add to the evidence that patients with blunt and penetrating trauma have different immediate needs. Several large studies have demonstrated an association between trans-



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