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Original Research

Ground Versus Air: Which Mode of Emergency Medical Service Transportation Is More Likely to Crash?

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ABSTRACT

Objective: We analyzed helicopter emergency medical services (HEMS) and ground emergency medical services (GEMS) crash data in the United States during 1983 to 2020 to compare incidences of total, fatal, and injury crashes.

Methods: HEMS and GEMS total, fatal, and injury crashes during 1983 to 2020 and 1988 to 2020, respectively, were analyzed in this retrospective study. Data were obtained from the National Transportation Safety Board and the National Highway Traffic Safety Administration. Additional data from the Federal Aviation Administration, the National Emergency Medical Services Information System, and prior literature were used for rate calculations. A Poisson regression model was used to determine rate ratios with 95% confidence intervals comparing total, fatal, and injury crash rates from 2016 to 2020.

Results: HEMS crash rates decreased since 1983. Total GEMS crashes have increased since 1988. Of the total crashes, 33% (HEMS) and 1% (GEMS) were fatal, and 20% (HEMS) and 31% (GEMS) resulted in injury. During 2016 to 2020, GEMS crash rates were 11.0 times higher than HEMS crash rates (95% confidence interval, 5.2-23.3; $P < .0001$).

Conclusion: HEMS has a lower crash probability than GEMS. The availability of data is a limitation of this study. National GEMS transportation data could be useful in studying this topic further.

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The use of helicopter emergency medical services (HEMS) to transport severely injured trauma patients has substantially increased over the past 2 decades.[1] By reducing transport time, increasing access to tertiary care facilities, and providing advanced resources, the literature suggests that HEMS improves the likelihood of survival and reduces mortalities after severe trauma.[1-3] Helicopters can be particularly useful in remote or mountainous areas that are not easily accessible by ground ambulances, and they can transport experienced medical teams to manage complex patients and transport them to distant locations.[1-4]

Despite their utility for transporting critically ill and injured patients, the safety of HEMS has long been questioned.[5] HEMS crewmembers had a death rate much higher than the occupational death rate for all US workers in 2006.[6] According to Baker et al,[6] in 2006, an HEMS crewmember flying 20 hours per week over a 20-year career would have a 37% chance of being in a fatal crash. Even so, crashes pose an occupational hazard for all emergency medical services (EMS) crews. Motor vehicle crashes are among the leading cause of occupational fatalities for ground emergency medical services (GEMS) crews.[7] One study found that 74% of EMS fatalities from 1992 to 1997 resulted from ground and air ambulance transportation accidents.[8] Another study found that 45% of occupational fatalities among emergency medical technicians and paramedics from 2003 to 2007 were related to motor vehicle incidents, whereas only 31% were related to aircraft crashes.[9] A third study found that ground ambulance crashes are about 10 times more likely to occur than helicopter accidents.[10]

Most studies reviewing GEMS and HEMS crashes are many years old. Technological advances and Federal Aviation Administration (FAA) regulations have been put in place to enhance HEMS

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safety.[7,11,12] Although motor vehicle safety measures have also significantly improved, there are still many areas of risk. Compliance with wearing seat belts in ambulances is poor,[13] and ambulances are permitted to disobey normal traffic laws in certain circumstances. Critical medical situations may cause anxiety that contributes to reckless driving.[14] More current findings could provide better guidance on the risks associated with EMS transportation.

No prior studies have directly compared the incidence of helicopter and ground ambulance crashes in the United States. The objective of this study was to observe trends in HEMS and GEMS data and to compare the incidence of HEMS and GEMS crashes in the United States.

Methods

For this retrospective study, we analyzed HEMS data from the National Transportation Safety Board (NTSB),[15] the FAA,[16] and prior studies.[17,18] We analyzed GEMS data from the National Highway Traffic Safety Administration (NHTSA) General Estimates System (GES), Fatality Analysis Reporting System (FARS), and Crash Report Sampling System (CRSS)[19] as well as the 2020 National Emergency Medical Services Information System (NEMSIS) Public-Release Research Dataset.[20] Figure 1 summarizes the information obtained from each database and the time period covered. None of the data sets used contain information that identifies patients, EMS agencies, or receiving hospitals. The study was reviewed and approved by the Penn State College of Medicine Institutional Review Board.

Helicopter Air Ambulance Data Analysis

The NTSB aviation accident database reports civil aviation accidents and serious incidents within the United States. Accidents in which any person suffers death or serious injury or in which the aircraft receives substantial damage must be investigated by the NTSB. Incidents that do not meet these personal injury or aircraft damage thresholds are not included in the NTSB aviation accident database.[21] The Case Analysis and Reporting Online (CAROL) database includes NTSB investigations from 1983 through present.

The CAROL query advanced search, the NTSB's query tool,[15] was used to identify helicopter crashes using the following search criteria:

- Event date from January 1, 1983, to December 31, 2020
- Country is the United States
- Aircraft category is helicopter
- Aviation fields: Operation: Air medical
- Aviation fields: Operation: FAR Part is Part 91: General Aviation or Part 135: Air taxi and commuter

Incidents that met the search criteria were imported into Excel for Mac (Version 16.61; Microsoft, Redmond, WA).

Upon request, the FAA provided the total hours flown by HEMS annually from 2016 to 2020. The total flight hours from 2002 to 2013 were obtained from Aherne et al.[18] The total flight hours from 1980 to 2002 were obtained from Blumen et al.[17] Data were used to assess changes in HEMS crash rates from 1983 to 2020.

Ground Ambulance NHTSA Data Analysis

Data from NHTSA's GES,[22] FARS,[23] and CRSS[24] provided total, fatal, injury, and property damage–only GEMS crashes from 1988 to 2020.[19] NHTSA's FARS is a nationwide census that reports all fatal motor vehicle crashes in the United States.[23] To be included in FARS, a crash must involve a motor vehicle traveling on a public road and must result in the death of a vehicle occupant or a nonoccupant within 30 days of the crash.[23] NHTSA's GES and CRSS include police-reported crashes involving all types of motor vehicles, including property damage–only crashes as well as those that result in injuries and/or fatalities. The GES includes data from 1988 to 2015, and the CRSS includes data from 2016 to 2020.[22,24] NHTSA data were used to

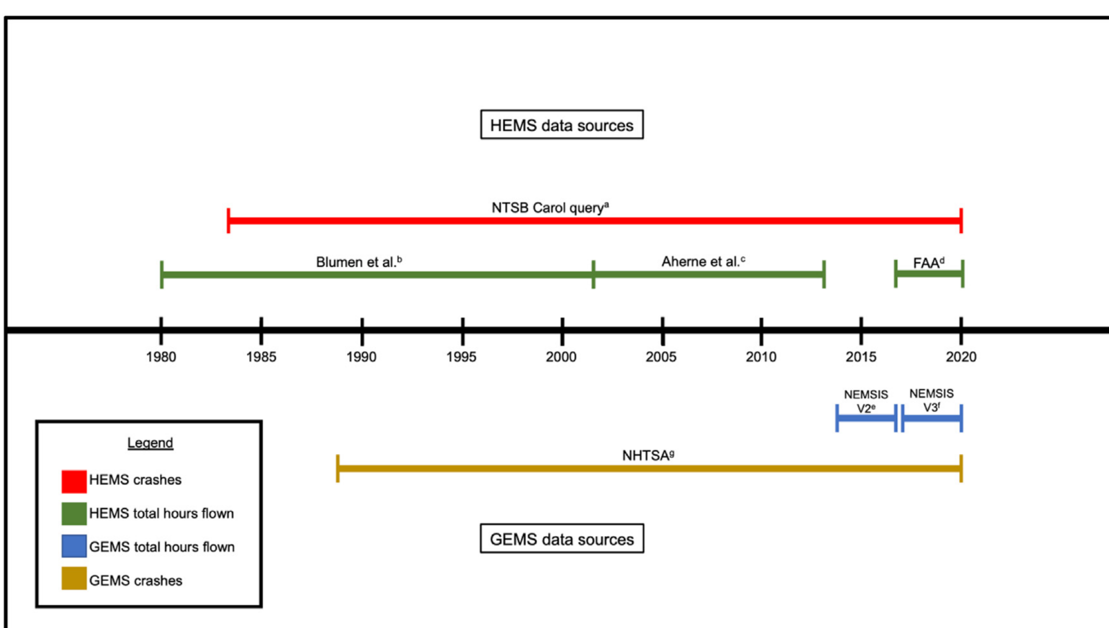

Figure 1. A summary of the HEMS and GEMS data sources used. [a]The total, fatal, and injury HEMS crashes from 1983 to 2020 were obtained from an NTSB CAROL query.[15] [b]The total hours flown by HEMS annually from 1980 to 2002 were obtained from Blumen et al.[17] [c]Estimates for the total hours flown by HEMS annually from 2002 to 2013 were obtained from Aherne et al.[18] [d]The total hours flown by HEMS annually from 2016 to 2020 were obtained by special request from the FAA.[16] [e]Estimates for the total hours flown by GEMS annually from 2014 to 2016 were calculated using data from the NEMSIS V2 database.[20] NEMSIS V2 also provided the number of crashes that occurred during GEMS response or transport. [f]Estimates for the total hours flown by GEMS annually from 2017 to 2020 were calculated using data from the NEMSIS V3 database.[20] NEMSIS V3 also provided the number of crashes that occurred during GEMS response or transport. [g]The total, fatal, and property damage–only GEMS crashes from 1988 to 2020 were obtained from NHTSA's GES, FARS, and CRSS.[19]

identify trends in total, fatal, injury, and property damage–only crashes from 1988 to 2020.

Ground Ambulance NEMSIS Data Analysis

Additional GEMS data were obtained from the 2020 NEMSIS Public-Release Research Dataset[20] to determine the total GEMS hours driven annually. This information was necessary to compare crash rates with HEMS, but the NEMSIS EMS Data Cube only has publicly available data during 2014 to 2020.

The NEMSIS V3 data set identified ground ambulance responses and transports from 2017 to 2020, and the NEMSIS V2 data set identified the same data from 2014 to 2016 using the data elements noted in Table 1.[20] The primary analysis included all activations of ground transport ambulances. The Centers for Medicare & Medicaid Services (CMS) service level was used to exclude air ambulances (fixed wing and rotary wing) from the analysis. Activations missing the CMS service level were also excluded. NEMSIS reports response and transport delays for each activation, including delays resulting from crashes involving ground transport units. Crashes were identified using "type of response delay–vehicle crash involving this unit" and "type of transport delay–vehicle crash involving this unit" filters. NEMSIS also reports average call times, including response and transport times, for each activation. This method excludes ambulance crashes that did not result in a response or transport delay as well as crashes that occurred when the ambulance was not responding to a call or transporting patients. We modeled this analysis after a study by Watanabe et al[25] that used NEMSIS to assess GEMS crash risk.

The total hours driven by ground ambulances annually were estimated using the following equation: $T = (r + t)c$, where T = the total hours driven, r = the average response time, t = the average transport time, and c = the number of activations.

The total number of crashes and the total hours driven were used to calculate annual crash rates per 100,000 hours driven from 2014 to 2020. The number of crashes, transports, and responses were also used to determine crash rates per 100,000 responses/transports for comparison with other studies.

The total hours driven (from NEMSIS data) were also used to calculate fatal and injury crash rates for further comparison with HEMS. However, NEMSIS does not provide the number of fatal or injury ground ambulance crashes. This information was obtained from the NHTSA,[19] but NHTSA data are representative of all ground ambulance crashes in the entire country. NEMSIS is a convenience sample collected from participating EMS agencies in the United States.[26]

Because of the discrepancy in sample size among different data sources, GEMS fatal and injury crash rates were extrapolated using the following equation:

$$R = \frac{\left(\left(\frac{a}{b}\right) \times c\right)100,000}{d}$$

where R = the crash rate, a = the total crashes (NEMSIS), b = the total crashes (NHTSA), c = fatal or injury crashes, and d = the total hours driven (NEMSIS).

Ground Versus Helicopter Ambulance Data Analysis

We report the total number of crashes as well as fatal, injury, and property damage–only crashes that occurred during ground and helicopter air ambulance responses and/or transports annually from 1988 to 2020 and 1983, respectively. We report HEMS total hours flown and the total, fatal, and injury crash rates per 100,000 hours flown annually by HEMS from 1983 to 2020, excluding 2014 to 2015. We report the same data for GEMS from 2016 to 2020. All data were assessed for outliers.

A Poisson regression model was used to determine rate ratios with 95% confidence intervals (CIs) for the association between the mode of transportation (ground or helicopter) and the total, fatal, and injury crash rates from 2016 to 2020. This period was chosen because these were the only years for which crash rates could be calculated for both HEMS and GEMS. Explanatory variables included the year and type of transport. The offset included in the model was the total hours driven/flown. Overdispersion of the model was confirmed by examining the residuals and the deviance statistic. Because of overdispersion, a scale parameter was added to the model. A negative binomial model was also tried because of the zero counts, but it did not fit well. Data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

Helicopter Air Ambulance Crashes

The NTSB CAROL search and literature review identified 323 HEMS crashes from 1983 to 2020. Of these, 108 crashes (33%) were fatal, 78 (24%) resulted in injury(ies), and 137 (42%) resulted in property damage only. Table 2 provides total, fatal, and injury crashes. Two outliers were found for HEMS injury crashes: 7 crashes in 2001 and 2003. Given the limited availability of data, we elected to include these values in further calculations after confirming their accuracy.

HEMS crash rates have declined from 11.05 crashes per 100,000 flight hours in 1983 to 1.01 crashes per 100,000 flight hours in 2020. The rate of fatal crashes has also decreased from 8.35 fatal crashes per 100,000 flight hours in 1985, plateauing between 0 and 2.14 fatal crashes per 100,000 flight hours since the early 1990s. The rate of injury crashes increased in the 2000s, ranging from 2 to 7 injury crashes annually. It plateaued at 0 to 3 injury crashes annually after 2010. Figure 2 summarizes these findings.

Ground Ambulance Crashes: NHTSA

The NHTSA FARS, GES, and CRSS 1988 to 2020 data set included 159,593 total GEMS crashes, 919 (1%) of which were fatal. Injuries resulted from 49,047 (31%) crashes, and 109,626 (69%) resulted in property damage only. The total GEMS crashes increased from 4,499 crashes in 1988 to 7,165 crashes in 2020. Fatal crashes remained between 16 and 43 annually during 1988 to 2020. Injury crashes ranged from 595 to 2,290 annually during the same period. The proportion of crashes that were fatal has generally decreased since 1988, but these values are all 1% or less. One outlier was found in GEMS

Table 1
National Emergency Medical Services Information System (NEMSIS) V2 and V3 Data Elements Used

NEMSIS Element	Use	V2 Element	V2 Data Used	V3 Element	V3 Data Used
Type of response delay	Outcome measure	E02_07	175 Vehicle crash	eResponse.09	2209025 Vehicle crash involving this unit
Type of transport delay	Outcome measure	E02_09	315 Vehicle crash	eResponse.11	2211025 Vehicle crash involving this unit
CMS service level	Exclusion criteria	E07_34	1025 Fixed wing (airplane) 1030 Rotary wing (helicopter) -25 Not applicable -15 Not reporting -5 Not available -20 Not recorded -10 Not known	ePayment.50	2650011 Fixed wing (airplane) 2650017 Rotary wing (helicopter) 7701001 – Not applicable 7701003 – Not recorded
Unit notified by dispatch date/time	Multivariable adjustment	E05_04	2014, 2015, 2016	eTimes.03	2017, 2018, 2019, 2020

Table 2
Ground (GEMS) and Helicopter Emergency Medical Services (HEMS) Total, Fatal, and Injury Crashes From 1983 to 2020

	GEMS[a]			HEMS[b]		
Year	Total	Fatal Crashes	Injury Crashes	Total	Fatal	Injury Crashes
1983[c]	—	—	—	5	2	1
1984[c]	—	—	—	7	2	1
1985[c]	—	—	—	11	6	4
1986[c]	—	—	—	11	4	4
1987[c]	—	—	—	2	1	0
1988	4,499	24	1,610	5	2	1
1989	3,577	28	1,558	7	3	1
1990	2,379	24	806	1	0	0
1991	2,843	39	1,334	1	1	0
1992	3,937	41	1,156	3	2	0
1993	4,169	31	1,923	3	2	1
1994	3,400	37	1,517	6	4	1
1995	4,142	36	975	8	1	1
1996	4,355	25	1,247	2	1	0
1997	4,799	29	1,457	4	2	1
1998	4,541	24	2,207	8	4	2
1999	5,088	16	1,852	10	3	3
2000	6,545	29	2,123	13	4	2
2001	3,920	25	1,247	14	2	7[d]
2002	4,062	20	2,064	14	5	3
2003	3,690	27	1,696	21	4	7[d]
2004	4,247	32	563	13	6	2
2005	4,752	43[d]	1,841	15	6	2
2006	4,789	22	1,504	15	3	4
2007	4,082	30	1,028	10	2	2
2008	6,014	28	1,384	14	7	4
2009	3,054	30	1,045	13	2	3
2010	5,498	26	1,497	15	6	1
2011	3,739	20	1,700	4	1	1
2012	5,179	30	1,290	9	1	2
2013	5,742	17	1,506	9	5	2
2014	6,881	22	1,794	8	2	2
2015	5,627	25	1,353	8	6	0
2016	6,780	23	1,540	9	1	3
2017	6,761	16	1,401	7	2	3
2018	6,936	40	1,038	5	0	2
2019	6,402	31	1,530	9	3	3
2020	7,165	29	2,261	4	0	2

[a] GEMS data obtained from the National Highway Traffic Safety Administration.[19]
[b] HEMS data obtained from the National Transportation Safety Board Case Analysis and Reporting Online query.[15]
[c] GEMS data not available during these years.
[d] Outliers.

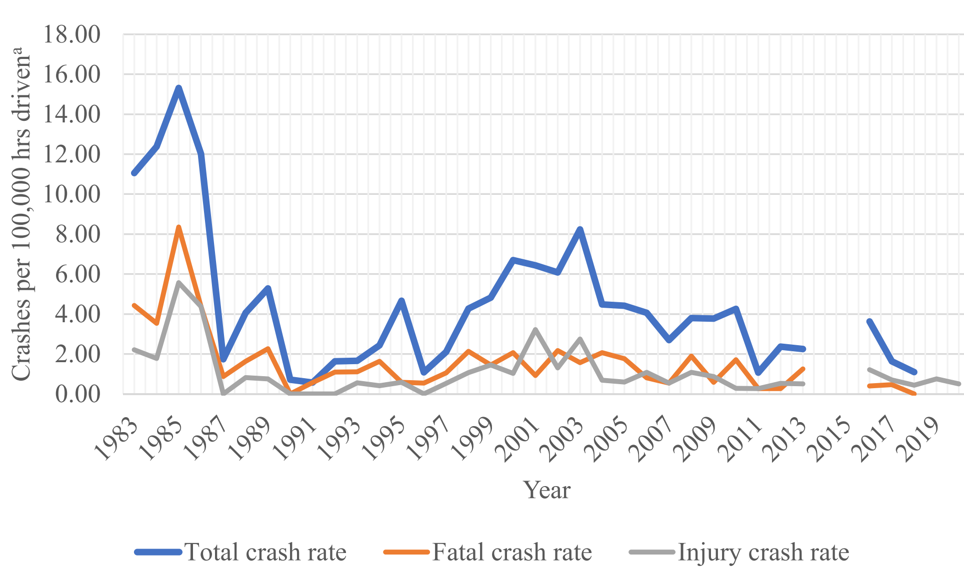

Figure 2. HEMS crash rates per 100,000 hours flown from 1983 to 2020. [a]Data obtained from the NTSB.[15]

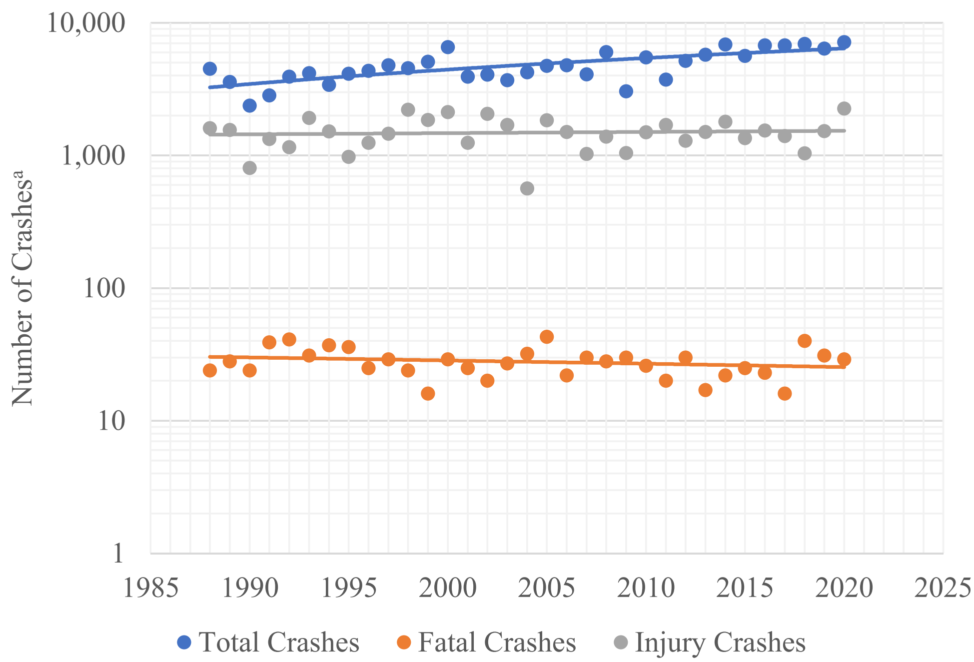

Figure 3. The GEMS total, fatal, and injury crashes. [a]Obtained from the NHTSA.[19]

fatal crashes: 43 fatal crashes in 2005. Given the limited availability of data, we elected to include this value after confirming its accuracy. Table 2 and Figure 3 summarize these findings.

Ground Ambulance Crashes: NEMSIS

The NEMSIS V2 data set includes 83,477,948 activations during 2014 to 2016. Of these, 429,880 were air ambulances, and 39,425,488 did not report the CMS service level. The remaining 43,622,580 activations were ground ambulances. The NEMSIS V3 data set includes 119,512,240 activations during 2017 to 2020. Of these, 443,431 were air ambulances, and 70,637,731 did not report the CMS service level. The remaining 48,431,078 activations were ground ambulances.

Table 3 summarizes the total hours driven, total crashes, and crash rate per 100,000 hours. Table 3 also reports the fatal and injury crash rates per 100,000 hours. No outliers were found in the GEMS NEMSIS data. There were 12.2, 5.40, 6.20, 4.40, and 17.5 crashes per 100,000 transports in 2016, 2017, 2018, 2019, and 2020, respectively.

Ground Versus Helicopter Air Ambulance Crashes

NTSB and NHTSA data reveal that a larger proportion of HEMS crashes are fatal compared with GEMS, but GEMS has a higher proportion of injuries. This is shown in Figure 4.

Using rate calculations extrapolated from NEMSIS and NTSB data, the GEMS crash rate was 11.0 times higher than the HEMS crash rate (95% CI, 5.23-23.3; $P < .0001$) from 2016 to 2020. The HEMS fatal crash rate was 3.74 times higher than the GEMS fatality rate (95% CI, 0.921-15.2; $P = .0650$). However, this difference is not statistically significant. The ground ambulance crash injury rate was 7.13 times higher than the helicopter ambulance crash injury rate (95% CI, 3.21-15.8; $P < .0001$).

Discussion

The emergency medical transport of patients, by air or by ground, can be dangerous. Of the many publications that examine ground ambulance transport, most identify serious risk from intersection collisions, high speeds, lights and sirens usage, and failure to use restraint systems.[8,27-34] The HEMS literature points toward night flights and poor weather conditions as the biggest risk factors.[5,6,17,18,35,36] Both air and ground EMS crashes often involve some sort of skill-based error.[32,37] This may be failure of a visual scan, such as flight into an obstacle or inadequate clearance at an intersection.[31,32] Both air and ground operators can be impacted by a failure of critical thinking, such as not considering weather conditions, using inappropriate procedures, or rushing.[14,18,38] In addition to fatigue, overconfidence or recklessness may play a role in faulty decision making.[14,32,38]

Ground and air EMS operations are subject to vastly different regulations. Although the federal government oversees HEMS operations, GEMS safety regulations vary significantly from state to state. Until recently, because of their size, ambulances did not need to meet most of the same crash testing requirements as cars.[8,39] In 1976, the US government outlined a set of specifications in a General Services Administration document called the KKK-A1822 (Triple-K) requirements.[40] Aside from the seating configuration in the patient care compartment and safety restraint requirements, most of the Triple-K requirements focus on the automotive aspects of the vehicle rather than the safety aspects. Other groups, such as the National Fire Protection Association and the Commission on Accreditation of Ambulance Services, have also published ambulance design standards.[41] However, although Triple-K standards are the most widely used, there is no federal mandate to adopt any particular standard. Nearly all states regulate local agencies that provide ambulance services. Six states have no ambulance design regulations, and only 1 state has specific training and certification requirements for ambulance drivers. Additionally, there are generally no duty hour restrictions for ground ambulance drivers.[42]

The FAA has the authority to oversee and regulate safety in the airline industry and the use of US airspace by both civil and public aircraft, including HEMS operations. As part of its authority, the FAA has developed and administers an extensive system of aviation safety certification and regulation.[11] HEMS operators holding Part 135 certificates are required to submit annual reports to the FAA that provide information about their operations, including the number of accidents, flights, and hours flown.[12] Part 135 regulations impose a high standard of pilot qualifications, including drug and alcohol testing for the flight crew. Many HEMS flights operate under

Table 3
Helicopter (HEMS) and Ground Emergency Medical Services (GEMS) Crash, Injury, and Fatality Totals and Rates per 100,000 Hours Driven/Flown From 2014 to 2020

Year	Total Hours Driven/Flown		Total Crashes		Crash Rate per 100,000 Hours Driven		Fatal Crashes		Fatal Crash Rate per 100,000 Hours Driven		Injury Crashes		Injury Crash Rate per 100,000 Hours Driven	
	GEMS[a]	HEMS[b]	GEMS[a]	HEMS[c]	GEMS[a]	HEMS[d]	GEMS[e]	HEMS[d]	GEMS[e]	HEMS[d]	GEMS[e]	HEMSd	GEMS[e]	HEMS[d]
2020	9,265,834	397,321	3,174	4	34.25	1	12.85	0	0.139	0	1,001.59	2	10.81	0.503
2019	7,751,513	399,251	633	9	8.17	2	3.07	3	0.040	0.75	151.28	3	1.95	0.751
2018	5,856,965	457,623	692	5	11.81	1	3.99	0	0.068	0	103.56	2	1.77	0.437
2017	2,344,139	430,804	253	7	10.79	2	0.60	2	0.026	0.46	52.43	3	2.24	0.696
2016	6,973,161	428,526	1,720	9	24.67	2	5.83	1	0.084	0.23	390.68	3	5.60	0.700

[a] Extrapolated from National Emergency Medical Services Information System data.[20]
[b] Provided by the Federal Aviation Administration.[16]
[c] Provided by the National Transportation Safety Board.[15]
[d] Calculated with Federal Aviation Administration and National Transportation Safety Board data.
[e] Extrapolated from National Emergency Medical Services Information System and National Highway Traffic Safety Administration[19] data.

Part 91, which are noncommercial flights. Some air medical helicopters operate under both Part 91 and Part 135 depending on the nature of each flight. Part 91 has less stringent safety and reporting requirements compared with Part 135. Part 135 has strict safety requirements including weather, visibility, and runway length restrictions.[11] Pilots need higher qualifications and have duty hour restrictions when operating under Part 135, whereas Part 91 has no duty hour limitations.[43]

In the mid to late 2000s, the alarming number of HEMS crashes resulted in the extensive adoption of safety technologies including terrain awareness warning systems and weather regulatory improvements, which may have led to a decrease in HEMS accidents.[44] The data from this study and prior studies[5,6,17,18] suggest a trend toward fewer HEMS crashes over the past 40 years.

Ground ambulance safety initiatives also began in the 2000s when the National Institute for Occupational Safety and Health partnered with the Ambulance Manufacturers Division of the National Truck Equipment Association and the General Services Administration to revise ambulance purchase specifications and Ambulance Manufacturers Division of the National Truck Equipment Association test standards. This included safety efforts such as increasing the head clearance for EMS workers above the seating positions and establishing a new crash test methodology.[45]

Despite these advances in safety, the number of GEMS crashes has increased, from 2,380 in 1990 to 7,165 in 2020. However, the number and usage of ambulances have also increased.[46,47] Data regarding the total hours driven is unavailable on a national scale before 2014, but this information is necessary to calculate crash rates per 100,000 hours driven. Crash rates provide a more accurate assessment of crash risk and facilitate comparison with HEMS.

Some studies have determined GEMS crash rates per 100,000 responses/transports. Auerbach et al[14] analyzed 102 ambulance crashes reported to the Tennessee Department of Health and Environment from 1983 to 1986, revealing a crash rate of 21.2 crashes per 100,000 ambulance responses. Bruhn et al[10] surveyed ground ambulance companies in the Massachusetts area in 1993 and determined crash rates of 55 per 100,000 GEMS transports. Watanabe et al[25] used the 2016 NEMSIS data set to determine a national GEMS crash rate of 9.3 per 100,000 transports. We calculated GEMS crash rates ranging from 4.4 to 17.5 crashes per 100,000 transports from 2016 to 2020 using NEMSIS data.

In this study, we primarily used crash rates per 100,000 hours driven. This is a more reliable indicator of crash risk because of variations of the length of transport, speed of travel, weather conditions, and vehicle or aircraft model. From 2016 to 2020, we found that GEMS was 11 times more likely to crash than HEMS in the United States. These results are consistent with prior research by Bruhn et al,[10] who found that GEMS is associated with approximately 10 times more accidents than HEMS in the Massachusetts area.

To reduce avoidable incidents, decisions must be grounded in a firm culture of safety. Whether by air or ground, risk mitigation must be part of all EMS operations. For example, there are numerous studies that note the minimal impact of the use of emergency lights and sirens on response times and patient outcomes.[34,48-50] Emergency medical dispatch protocols must constantly re-examine the risk versus benefit of emergency response and lights and siren transport. Similarly, HEMS programs should be reviewing the use of predesignated landing zones (ie, vetted, approved areas where helicopters can safely land with minimal to no obstructions). The FAA promotes the use of a "safety management system," a formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls.[51] Mirroring this for ground EMS could be monumental for improving safety.

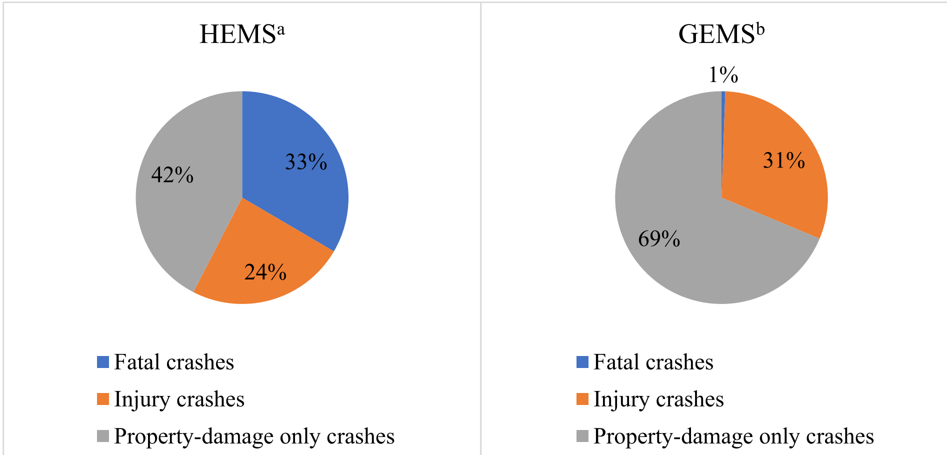

Figure 4. The percentage of fatal, injury, and property damage–only HEMS and GEMS crashes. [a]HEMS data from 1983 to 2020. Retrieved from an NTSB CAROL query.[15] [b]GEMS data from 1988 to 2020. Obtained via a NHTSA request.[19]

Limitations

The limited availability of cohesive data on both ground and helicopter ambulance transports is a major limitation of this study. We made several assumptions when calculating crash rates and were unable to compare HEMS and GEMS for all years studied because of data limitations. Ground ambulances are not subject to the same reporting requirements as helicopter air ambulances, and this reduces the amount of data available for studying trends in ground ambulance crashes.

HEMS data regarding the total hours flown were obtained from several sources, including the FAA and prior research[17,18] that estimated the total flight hours from NTSB data, surveys, and extrapolations from other studies. HEMS data are also limited by less stringent reporting requirements for Part 91 compared with Part 135, potentially excluding some air medical crashes operating under Part 91.[43]

The GEMS total hours driven were extrapolated from NEMSIS data during 2014 to 2020. NEMSIS is a convenience sample consisting of data submitted by participating EMS agencies and relies on the accuracy of the files received from the contributing agencies. Events submitted by states to NEMSIS do not represent all EMS events occurring within a state, and states may vary in criteria used to determine the types of EMS events submitted to NEMSIS.[26] Annual variation in agencies reporting to NEMSIS is a possible source of error. NEMSIS received data from 12,319 EMS agencies in 50 states and territories in 2020 but that only represented about half of the total number of EMS agencies in the United States.[26] Older NEMSIS data come from an even smaller proportion of EMS agencies in the United States. Only 9,653 agencies reported to NEMSIS in 2014.[26] NEMSIS reporting transitioned from the V2 to V3 database in 2017.[26] This transition may have contributed to the decrease in ground ambulance accident rates in 2017, 2018, and 2019 because of a decrease in reporting as agencies adjusted to V3. In addition, NEMSIS only reports crashes that result in response or transport delay. This may exclude minor crashes that were not reported or did not result in a delay as well as crashes that occurred when ambulances are returning to the station after completing a call.

Conclusions

Ground ambulance transport was associated with increased crash rates compared with helicopter ambulance transport. Although HEMS was associated with greater fatality rates than GEMS, this difference was not statistically significant. This study suggests helicopter transport has a lower risk of crashing than ground transport. However, the restricted availability of data makes it challenging to accurately assess crash risk.

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