2024 UPDATE to Spicer et al. (2021): The Frequency and Cost of Crashes Involving Disabled Vehicles

With a focus on commercial vehicles

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Abstract

Objective: In a previous study, Spicer et al. (2021) found that an estimated 1.55 fatalities and nearly 40 injuries per day occur in low conspicuity events involving passenger vehicles every year, and highlighted the risks to a special subset of pedestrians: motorists who exited their vehicles to attend to a disabled or stopped vehicle. The current study updates the total number and cost of crashes, fatalities, and injuries by adding low conspicuity crashes involving stopped or parked commercial vehicles. These crashes might be prevented with improved advanced warning to approaching traffic of the disabled vehicle or the stopped commercial truck.

Methods: Using the Fatality Analysis Reporting System (FARS) and the Crash Report Sampling System (CRSS), this study defines three crash scenarios where insufficient conspicuity of a disabled vehicle ("low conspicuity emergency") or a stopped commercial truck resulted in injury or fatality. Scenario 1) Moving vehicle strikes non-moving vehicle following an initial event; Scenario 2) Pedestrian (primarily a motorist who has exited their vehicle) is struck while tending to a disabled or stopped vehicle; and Scenario 3) A vehicle departs the roadway, crashes unnoticed and rescue initiation is delayed significantly.

Results: Each year, from 2016 through 2021, an estimated 16,141 people were injured or killed in low conspicuity emergency events involving passenger vehicles. Each year an additional 4,422 people were injured or killed in crashes where a commercial vehicle was stopped or parked on delivery in the road or median. Most (97%) of these crashes occurred under scenario 1. Based on the FARS data, nearly 492 people were killed under scenario 1 each year and fatal cases have increased 48% since 2016. Notable is the severity of the scenario 2 crashes that accounted for just 3% of overall low conspicuity events but 33% of all fatalities. Scenario 2 is responsible for 276 fatalities each year and have increased 42% since 2016. Overall, crashes under these three scenarios resulted in an annual estimated $16.5 billion in societal costs, including the economic costs of medical payments and wage loses in addition to the value of quality of life lost due to death or disability. Commercial vehicle-involved crashes make up $5 billion of these costs.

Conclusions: A significant number of people die or are injured in low conspicuity events every year; approximately 2.3 fatalities, 54 injuries, and over 300 crashes per day. This analysis highlights the alarming ongoing increase in these events. These fatalities and injuries that result from crashes related to low conspicuity events are preventable. Countermeasures to reduce the incidence and severity of the crash scenarios include Move-Over laws, improved traffic management in hazardous situations, and new and innovative hazard lighting and advance warning technologies studied.

1. Introduction

In 2022, a total of 42,514 fatalities occurred as a result of motor vehicle crashes occurring on United States (U.S.) public roadways (NCSA, June 2024 revised). Of these, 35% were passenger car or light truck occupants, 5% were large truck or bus occupants, 15% were motorcycle riders and 21% were nonoccupants (mostly pedestrians and pedalcyclists). A study of pedestrian fatalities between 2009 and 2016 noted that pedestrian fatalities on interstates and other freeways increased by 60% during this period (Hu and Cicchino, 2018.)

Spicer et al. (2021) found that an estimated 1.55 fatalities and nearly 40 injuries per day occur in passenger vehicles involved in low conspicuity events every year, and highlighted the risks to a special subset of pedestrians: motorists who exited their vehicles to attend to a disabled or stopped vehicle. These crashes might be prevented with improved conspicuity to approaching traffic of the disabled vehicle or the stopped commercial truck on delivery. The current study updates the total number and cost of crashes, fatalities, and injuries resulting from passenger vehicle crashes where insufficient conspicuity of a disabled vehicle contributed, and adds estimates of crashes and injuries involving stopped or parked commercial vehicles on delivery and on the road.

2. Methods

This study examines three crash scenarios where insufficient conspicuity of a disabled vehicle (“low conspicuity emergency”) or a stopped commercial truck resulted in injury or fatality:

1) Moving vehicle strikes non-moving vehicle following an initial event,
2) Pedestrian is struck while tending to a distressed vehicle situation, and
3) A vehicle departs the roadway unnoticed and rescue initiation is delayed significantly.

The current study updates Spicer et al. (2021) and adds an estimate of counts, injuries, fatalities and costs for crashes involving commercial vehicles. A detailed description of the methods is available in Spicer et al. (2021), including scenario definition and key variables used to identify each sub-scenario.

2.2. Data Sources

Data from NHTSA’s 2016-2021 Fatal Analysis Reporting System (FARS) and the 2016-2021 Crash Report Sampling System (CRSS) were analyzed to quantify the number of fatalities and injuries attributed to the three scenario types defined in this study. Separately, the FARS 2016-2021 and CRSS 2016-2021 calendar year data were analyzed by merging crash, vehicle, person and event level data. Both data sources include U.S. crashes severe enough to result in a police report. Variable names are consistent between FARS and CRSS and therefore scenario definitions were consistent.

For this update, commercial vehicles were added to the analysis and defined using the body style variable in FARS and CRSS. Commercial vehicles included vans ('STEP VAN' 'VAN CAMPER' 'VAN CARGO' 'VAN PASSENGER' 'CUTAWAY') and Medium to Large trucks over 10,000 pounds gross vehicle weight rating ('AUTO TRANSPORTER' 'BUS NON SCHOOL' 'BUS SCHOOL' 'CAB CHASSIS' 'CEMENT MIXER' 'COMMERCIAL CHASSIS' 'DUMP' 'FLATBED' 'GARBAGE/REFUSE' 'FIRE TRUCK' 'LOWBED' 'MOTOR HOME' 'STRAIGHT TRUCK' 'TANK' 'TRACTOR TRUCK').

The CRSS data did not allow for identification of scenario 3 crashes (unnoticed vehicle roadway departure where rescue is delayed by more than 60 minutes). Therefore, the magnitude of this problem remains unknown.

2.3. Validating relevancy of crashes to each scenario using police accident reports

To validate the applicability of the FARS coding and assumptions made during analysis to categorize crashes by scenario, detailed police reports for the Florida crashes were acquired to confirm that low conspicuity contributed to the severity of the event or that, under ideal conditions, the crash may not have occurred if visual conspicuity were significantly increased. Depending on how well the narrative description met the study-defined crash scenarios and sub-scenarios, the percent of crashes determined applicable to the scenario definition was noted. These percentages were then used to adjust the number of crashes identified in the FARS and CRSS datasets.

2.4. Cost of crashes, fatalities and injuries

Unit costs, from Blincoe et al (2019) and inflated to 2021 dollars, were applied to the case populations by injury severity (KABCO). Costs included both economic and quality of life costs. Economic costs include the medical care, emergency services, insurance administration, workplace costs, legal costs, congestion, property damage, and lost productivity. Congestion costs include travel delay, added fuel usage, and adverse environmental impacts. Quality of life costs measure the non-monetary value of quality of life lost due to death and disability. Comprehensive costs are the economic plus the quality of life costs.

3. Results

The review of FARS cases, crash years 2016-2021, identified 6,313 fatalities that met the criteria defined for each scenario and sub-scenario. A total of 144 police records were acquired from Florida in order to validate the applicability of the FARS scenario definitions. Of these 144 records, 70 were scenario 1 (79% applicable), 68 were scenario 2 (81% applicable), and 6 were scenario 3 (100% applicable) cases. Overall, 120 (83%) of the 144 Florida cases were confirmed as applicable to the sub-scenario upon review. The percent applicable varied by sub-scenario from 50% (Scenario 2.6) to 100% (Scenarios 1.6, 2.5, and 3.1).

From 2016 through 2021, the number of fatalities and injuries (adjusted by percent applicable) increased (Table 1). Fatalities increased 48% for scenario 1 and 42% for scenario 2. Fatal scenario 3 incidents are less common in this period, with fatalities peaking in 2020 and dropping in 2021. Injuries increased and decreased under scenario 1 and increased 12% under scenario 2. The CRSS data did not allow for identification of scenario 3 crashes, however, the data show that Scenario 1 crashes increased by 13% and Scenario 2 by 39%.

Adjusted by percent applicable, 97% percent of crashes and 58% of fatalities occur under scenario 1, moving vehicle hits non-moving vehicle (Table 2). An additional 33% of fatalities occurred under scenario 2, and 9% of fatalities under scenario 3. The majority of these fatalities occurred under sub-scenarios 1.3 (Same Traffic way Disabled Vehicle on Road) and 2.1 (Pedestrian Attending to Disabled Vehicle on Road). Scenario 2 crashes are particularly severe when they occur: These 33% of fatalities occur in the three percent of crashes that are Scenario 2.

The distribution of scenarios involving commercial vehicles was distinctly different from those involving passenger vehicles. Just 60% percent of injuries and fatalities in commercial vehicle crashes occurred under scenario 1 compared to 91% of injuries and fatalities in passenger vehicle crashes (Table 2). However, scenario 1 injuries were more likely fatal among commercial vehicle crashes (8.2%) compared to passenger vehicle crashes (1.9%) (Table 2). In contrast, scenario 2 injuries were more likely fatal among passenger vehicle crashes (12.0%) compared to commercial vehicle crashes (6.3%).
These crashes resulted in an annual estimated $16.5 billion in societal costs, including the economic costs of medical payments and wage loses in addition to the value of quality of life lost due to death or disability (Table 3). Commercial vehicle-involved crashes make up $4.9 billion of these costs. Scenario 1

crashes result in $13.6 billion in losses, scenario 2 crashes in $1.9 billion in losses, and scenario 3 crashes in $1.0 billion in losses.

4. Conclusions

This study updates Spicer et al. (2021) and reports a more complete picture of the problem by adding crashes that involve commercial vehicles that were disabled, stopped or parked on delivery in the road or median. The study highlights that this problem continues to increase in all scenarios, but in particular in scenario 1.

Annually, an estimated average of 111,120 crashes involved a low conspicuity emergency event, resulting in an estimated 844 fatalities and an additional 19,720 non-fatally injured. This translates to approximately 2.3 fatalities, 54 injuries, and nearly 304 crashes per day. The larger burden of fatalities is among passenger vehicle crashes, accounting for 61% of these fatalities. Ninety-seven percent of crashes occur under scenario 1 (a moving vehicle hits a non-moving vehicle). Notable, however, is the severity of scenario 2 crashes (pedestrians attending to a stopped vehicle) where 8.8% of the resulting injuries are fatal.

Since Spicer et al. (2021) was published, fatalities and injuries due to these events continue to rise, highlighting the need for preventive and mitigating interventions. This study underlines the increasing risks to pedestrians who are attending to disabled or otherwise stopped vehicles. Hu and Cicchino (2018) reported a 60% increase in pedestrian fatalities on interstates and other freeways between 2009 and 2016. A follow-up study of the circumstances of these fatalities found that 18% were on the freeway because of a disabled vehicle (Wang and Cicchino, 2020.) The authors recommended improvements in road design, vehicle design and lighting and speed limit enforcement to address the problem.

A recent study reporting the increase in pedestrian deaths, identified that 85% of these increases are among fatalities occurring at night (Ferenchak and Abadi, 2021). In the current study of low conspicuity events, these cases are mostly motorists who have exited their vehicles with risk factors for collisions distinctly different from other pedestrians walking or standing on the road at night. These are motorists of primarily private vehicles and would not be covered by current Move-Over laws or traffic control policies and guidelines designed to protect responders in emergency vehicles. Therefore, technologies to improve conspicuity in emergency scenarios before responders arrive could prevent or mitigate the severity of these crashes. For example, enhanced and automated hazard lighting on vehicles at the time they are disabled or crash, and before emergency services arrive, is another countermeasure.

Policies to reduce secondary crashes when emergency services are responding to a traffic incident vary by state and may reflect different priorities, congestion conditions, and investment. These may include assigning a spotter to watch for oncoming traffic and ensure people are yielding and slowing down, and increasing on scene visibility with flares, safety cones and flashing lights. Move Over laws protect emergency responders and others involved in the incident. However, first responders continue to be killed and injured in secondary crashes to the incident they are responding to.

Move Over laws and traffic incident management practices are designed to protect emergency responders, workers and others who are stopped on the side of the road. They are in effect once emergency responders arrive. However, technologies designed to increase conspicuity that are triggered at the time of the crash or incident would protect much earlier and could therefore have an enhanced effect. Multiple states have now updated Move Over Laws to make them applicable when drivers are approaching any stationary vehicle (not just an emergency response vehicle) that is flashing its lights.

Vehicle hazard lighting, triggered manually or automatically can immediately convey a message to oncoming vehicles that a hazard exists. This message can differ depending on the combination of color, intensity, flash rate and flash pattern. Flannagan et al. (2005) found that that stronger warning lamps (in frequency and brightness) might reduce the risk of crashes in which another driver fails to detect an emergency vehicle. The authors noted that hazard lights did not prevent all crashes; in 30% of the crashes studied the non-emergency vehicle did not detect the emergency vehicle even though the hazard lights were on. However, the Flannagan (2005) study was performed before the current proliferation of LED lights on newer model year vehicles. More research is needed to better understand the characteristics of hazard lights that might prevent crashes in low conspicuity emergency events, in particular during the period before emergency vehicles arrive.

Estimating the economic burden of these crashes is important for setting priorities, allocating resources, and planning cost-effective prevention activities. As a metric of burden, costs account for multiple injury consequences—death, severity, disability—in a single unit of measurement (dollars). These costs include quality of life losses due to death and disability. This allows a comparison of burden between different scenarios. Annually, these crashes result in an estimated $16.5 billion in economic and quality of life losses annually. The distribution of cost by scenario differs from that of raw crashes because injury severity distributions differ – more severe injuries incur a greater burden and therefore a greater relative cost. Scenario 2 generally results in severe injury and fatality and accounts for 11.6% of the costs but just 3% of crashes. While 97% of crashes were under scenario 1, 82% of costs are due to scenario 1 crashes. Future evaluations of countermeasures can incorporate these cost estimates into a cost-effectiveness or cost-benefit analysis.

This study quantifies the consequences related to secondary crashes resulting from low conspicuity emergency events and expands on the Spicer et al. (2021) study to include commercial vehicle crashes. The burden of these crashes, injuries and fatalities is significant but may be prevented or mitigated through a combination of policies like Move Over laws, improved traffic management in hazardous situations, and new and innovative hazard lighting and advance warning technologies.

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Table 1. Estimated Number of Fatalities, Injuries and Crashes in Low Conspicuity Passenger and Commercial Vehicle Crashes, by Scenario and Crash Year (adjusted by percent applicable)

	Crash Year						Total
	2016	2017	2018	2019	2020	2021	
Fatals							
Scenario 1	427	457	487	463	482	634	2,949
Scenario 2	250	244	271	253	283	355	1,656
Scenario 3	59	89	70	60	99	80	457
Injuries*							
Scenario 1	19,795	13,333	16,767	15,175	17,818	18,249	101,138
Scenario 2	2,636	2,782	2,909	3,061	2,836	2,955	17,179
Crashes*							
Scenario 1	97,423	106,412	108,309	118,422	103,470	110,187	644,223
Scenario 2	1,159	1,285	1,806	1,546	1,506	1,614	8,916

**It is not possible to identify Scenario 3 with CRSS*

Table 2: Average Annual (2016-2021) Low-Conspicuity Passenger and Commercial Vehicle Crashes and Resulting Injuries and Fatalities, by Crash Scenario and Sub-Scenario (adjusted by percent applicable)

	Passenger Vehicle Crashes		Commecial Vehicle Crashes		Total Crashes		
Scenario	Non-Fatal Injuries	Fatal Injuries	Non-Fatal Injuries	Fatal Injuries	Crashes	Non-Fatal Injuries	Fatal Injuries
1.1	6,408	77	1,178	64	52,946	7,586	140
1.2	810	4	183	8	6,546	993	12
1.3	3,594	138	700	58	21,807	4,294	196
1.4-1.5	361	41	46	26	2,130	406	67
1.6-1.7	3,254	16	323	61	24,206	3,577	77
Scenario 1 Subtotal	**14,428**	**275**	**2,428**	**217**	**107,635**	**16,856**	**492**
2.1	399	127	706	56	1,466	1,104	182
2.2	112	8	155	31	351	267	40
2.3	113	11	120	13	271	233	25
2.4	485	13	576	6	1,183	1,061	19
2.5	81	2	86	5	179	167	7
2.6	12	2	18	1	34	30	3
Scenario 2 Subtotal	**1,201**	**163**	**1,662**	**113**	**3,485**	**2,863**	**276**
Scenario 3 Subtotal	**-**	**74**	**-**	**3**	**-**	**-**	**76**
Total	**15,629**	**512**	**4,090**	**332**	**111,120**	**19,720**	**844**

Table 3: Annual Cost of Fatalities and Injuries by Reported Severity and Crash Scenario, Adjusted by Percent Applicable (Cost in Millions of U.S. Dollars, Crash Years 2016-2021

	Economic Costs		**Quality of Life Costs**		
Scenario	Passenger Vehicle Crashes	Commercial Vehicle Crashes	Passenger Vehicle Crashes	Commercial Vehicle Crashes	**Overall Comprehensive Cost, including Economic and Quality of Life Costs**
1.1	$ 721	$ 224	$ 2,775	$ 1,018	**$ 4,738**
1.2	$ 76	$ 31	$ 273	$ 145	**$ 524**
1.3	$ 544	$ 165	$ 2,611	$ 820	**$ 4,141**
1.4-1.5	$ 109	$ 56	$ 617	$ 304	**$ 1,086**
1.6-1.7	$ 395	$ 173	$ 1,680	$ 855	**$ 3,103**
Scenario 1 Subtotal	$ 1,845	$ 650	$ 7,956	$ 3,141	**$ 13,592**
2.1	$ 287	$ 179	$ 1,583	$ 917	**$ 2,966**
2.2	$ 29	$ 79	$ 151	$ 409	**$ 667**
2.3	$ 33	$ 37	$ 174	$ 196	**$ 439**
2.4	$ 57	$ 51	$ 283	$ 213	**$ 604**
2.5	$ 11	$ 16	$ 57	$ 83	**$ 168**
2.6	$ 4	$ 4	$ 22	$ 19	**$ 49**
Scenario 2 Subtotal	$ 421	$ 186	$ 400	$ 920	**$ 1,927**
Scenario 3 Subtotal	$ 149	$ 5	$ 843	$ 30	**$ 1,027**
Total	$ 2,414	$ 842	$ 9,199	$ 4,091	**$ 16,546**

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