DROWNING DEATHS IN MOTOR VEHICLE TRAFFIC ACCIDENTS

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ABSTRACT

Very little is known about drowning deaths that occur as the result of motor vehicle traffic accidents. The two research questions addressed in this paper are how frequently do drowning deaths as a result of motor vehicle traffic accidents occur and what are the circumstances surrounding these deaths. The choice of the word "accident" instead of "crash" in this paper is intentional to avoid confusion related to the various source documents that define traffic and transport accidents.

The primary data source for this analysis is the linked Fatality Analysis Reporting System (FARS) – Multiple Cause of Death (MCoD) file that is produced by the National Highway Traffic Safety Administration's (NHTSA) National Center for Statistics and Analysis (NCSA) in collaboration with the Centers for Disease Control (CDC). The years used for the analysis start with 2004 and end with 2007.

From 2004 through 2007, there was an annual average of 384 traffic fatalities in FARS where accidental drowning was listed as one of the causes of death. Note, however, that this number may be slightly lower than the national total because of missing MCoD data from two States (Hawaii and Wisconsin). Also a few fatalities from December 2007 crashes may not have matching mortality data because the death occurred in January 2008.

Drowning fatalities are more common in some States than in others. The top five States, which are all large coastal States, accounted for slightly more than half of the total drowning deaths in the 48 States and D.C. The occupants' motor vehicles included a wide range of body types from passenger cars and pickups to motorcycles. However, the passenger vehicle category, which accounted for 94 percent of the drowning fatalities from 2004 through 2007, is the focus of this paper.

Overall 63 percent of the passenger vehicle drowning fatalities involved a rollover, and 12 percent involved a collision with another motor vehicle. The most common passenger vehicle crash scenario was a single-vehicle rollover accounting for 59 percent of the fatalities. These crashes frequently involved running off the road and colliding with a fixed object prior to the rollover and immersion. In cases with known restraint use, the victim was not using any form of restraint system 52 percent of the time.

Two types of motor vehicle related drowning deaths are not included in FARS based upon the American National Standards Institute's (ANSI) definition of a motor vehicle traffic accident. The first type is a drowning that occurs as the result of a nontraffic accident, which occurs off of public roads. While NHTSA collects information about nontraffic crashes, it does not have the multiple cause of death information to enable a similar analysis. The second type is a drowning as the result of a cataclysm, such as flooding, that is not a motor vehicle accident fatality per ANSI definitions. Including nontraffic and cataclysm cases would lead to a larger number of motor vehicle related drowning fatalities.

INTRODUCTION

Very little is known about drowning deaths in the United States that occur as the result of motor vehicle traffic accidents. While NHTSA's FARS database contains a census of all motor vehicle traffic fatalities, it does not contain the information needed to identify fatalities that resulted from drowning. Therefore not only are the circumstances surrounding these drowning deaths uncertain, the frequency of such deaths is also unknown. The purpose of this paper is to provide answers to both of these research questions by using a powerful dataset containing fatalities in FARS linked to mortality data from the CDC via death certificates.

This paper intentionally uses the term "accident" even though FARS now refers to all accidents as "crashes." One reason is the mortality coding, and the public health field in general, still use the term accident rather than crash. The second reason is that the choice of what to include in FARS, which is discussed in a later section, is based upon the ANSI definition of a "motor vehicle traffic accident." While the choice of accident is meant to avoid confusion related to these source documents, the term accident and crash are synonymous.

DATA AND METHODOLOGY

This paper uses underlying cause of mortality data from the CDC's National Center for Health Statistics (NCHS) that have been linked to the NHTSA's FARS database. The NCHS MCoD data set includes data on all recorded deaths that occur in the United States. Each record includes information from the decedent's death certificate about the underlying cause of death and multiple conditions that contributed to the death. The underlying cause of death may be internal morbid bodily conditions (natural causes) or external conditions such as injury, poisoning, and other adverse effects coded using the World Health Organization's (WHO) International Classification of Diseases, Tenth Revision (ICD-10).

Two sets of codes on conditions considered contributing causes of death are included for each data record in the MCoD files. The original death certificate coding is preserved in one set of codes. A second set of codes, known as record-axis codes, have been edited by NCHS to eliminate contradictions and to define the condition most precisely within the limitations of ICD-10 coding and the available medical information on the death certificate. This paper uses the record-axis coding as well as the ICD-10 underlying cause of death to identify drowning fatalities that resulted from a motor vehicle traffic accident.

Per ICD-10 coding instructions, a drowning death in a motor vehicle traffic accident would have an external cause or mechanism of "transport accident" rather than "accidental drowning and submersion." Drowning would be noted as a consequence of the external cause in one of the record-axes. Thus the external cause and the consequence code used together indicate drowning as the result or consequence of a transport accident. For example, the underlying cause of death may be "car occupant injured in noncollision traffic accident" (V48) or "unspecified motor vehicle traffic accident" (V892). The listed consequence of the accident would be "drowning as the effect of other external causes" (T751) in one of the 15 record-axes.

In some cases, drowning is the only recorded consequence of the motor vehicle traffic accident. In other cases, injuries from the crash are also listed as conditions contributing to the death. For example, a case may list drowning as well as other injuries. Common examples of the other injuries include "unspecified injury of head" (S099), "injury of unspecified body region" (T149), and "unspecified multiple injuries" (T07). This paper counts both situations as motor vehicle traffic drowning deaths.

Finally, in some cases it is not possible to determine whether drowning was involved. These cases include recorded deaths with an external cause but without any listed consequences, such as a motor vehicle traffic accident without any coded injuries, and FARS fatalities that could not be matched to a record in the MCoD file.

The years selected for this paper include linked FARS and MCoD data from 2004 through 2007. The beginning year of 2004 corresponds to the first year that FARS recorded the sequence of crash events for each vehicle that is used later in this paper. The end year of 2007 corresponds to the most currently available linked MCoD file. The analysis focuses only on occupants of motor vehicles and thus excludes nonoccupants such as pedestrians or bicyclists.

RESULTS

Drowning deaths based upon ICD-10 codes

Table 1 contains the annual average deaths in the linked FARS-MCoD 2004 through 2007 files by external cause and whether drowning was recorded as a contributing condition. The results indicate an annual average of 384 motor vehicle occupant traffic fatalities involved drowning, which is the sum of the three lines in Table 1 indicating a drowning. This average is 1 percent of all motor vehicle occupant fatalities where it was known whether drowning was involved, which is calculated by dividing the 384 cases of drowning by the sum of all cases with drowning involvement known as either yes or no (35,242).

Most of the fatalities indicate the expected coding of a transport accident with drowning as one of the consequences. The cases with drowning as the external cause also had an external cause of transport accident listed in the conditions contributing to the death. The cases without an external cause indicate that the underlying cause of death was an internal morbid bodily condition such as a disease of the nervous or circulatory system. However, since the drowning was listed as a contributing condition, this situation is included here for completeness.

Table 1.
Motor vehicle traffic fatalities
by external cause and resulting injuries

External Cause	Drowning?	Annual Average
Transport	Yes	381
Transport	No	34,585
Transport	Unknown	106
Drowning	Yes	<1
Other	No	23
None	Yes	2
None	No	251
None	Unknown	71
Unknown	Unknown	1,527
TOTAL		36,946

Note: Drowning fatalities shaded in table.

Table 1 also shows that for about 5 percent of the fatalities it is not possible to determine whether the person drowned. In some cases the mortality data does not contain any injuries related to an external cause. More frequently, however, there is no mortality data linked to the FARS fatality. The linked FARS-MCoD file does not contain any mortality data from Hawaii or Wisconsin, and it lacks mortality data from New Jersey for 2007. It is also the case that some fatalities associated with crashes in December 2007 may not have mortality data because the death occurred in January 2008. The percent of FARS occupant fatalities for which drowning could not be determined ranged from 3 percent in 2006 to 8 percent in 2004. Therefore, all of the counts in this report represent most of the deaths from 48 States and the District of Columbia. National totals, however, would likely be larger by about 5 percent.

Comparing drowning deaths to FARS immersions

FARS does not have a code to indicate drowning, which is why drowning deaths were identified using the linked FARS-MCoD file. However, since 2004 FARS has included a set of variables that capture the events in the crash related to each vehicle. The FARS analysts are instructed to include both collision and non-collision events regardless of injury or property damage for each vehicle in the order that the events occurred. One of the possible events is "immersion," meaning immersed in a body of water.

The maximum number of events that can be listed for each vehicle is six. If immersion is one of the six listed events, then the vehicle is categorized as an "immersion" for this paper. If there are five or less events and immersion is not one of the events, then the vehicle is not an immersion case. Finally, if there are six events and immersion is not one of them, then immersion status is unknown because it could have occurred as a seventh or later event. This special case, which affects less than 100 fatalities per year, is treated as unknown even though it is possible that there were exactly six events and none of them were drowning.

Note also that immersion is a vehicle-level variable meant to provide information about the vehicle. It does not directly tell us about drowning deaths because some or all of the occupants of the immersed vehicle may have survived and fatally injured occupants could have died of crash injuries rather than drowning. However, there is interest in knowing whether fatally injured occupants in immersed vehicles are all or mostly drowning deaths. If there is close correspondence between fatally injured occupants of immersed vehicles and drowning deaths, then immersion could be considered a proxy for drowning deaths.

Table 2 shows the correspondence between whether immersion was included in the sequence of vehicle events and whether a drowning death occurred within the vehicle. The 384 drowning fatalities from Table 1 occurred in 339 vehicles. Overall Table 2 demonstrates that immersion is not a good predictor of whether the occupant fatalities involved drowning. Of the 332 vehicles with an immersion status of "yes" or "no" and a drowning death in the vehicle, immersion was included in the sequence of events only 61 percent (203/332) of the time. Among the 384 vehicles where immersion was recorded in the sequence of events including both vehicles with and without a drowning death, only 53 percent (203/384) had a known drowning fatality.

Table 2.
Immersed vehicles by whether an occupant of the vehicle drowned

Immersion in Sequence of Events?	Annual Average with Drowning Death	Annual Average without Drowning Death	TOTAL
Yes	203	181	384
No	129	31,555	31,684
Unknown	7	1,524	1,531
TOTAL	339	33,260	33,599

Immersed vehicles without a drowning death could be situations where the occupants died of injuries

other than drowning. Drowning deaths where the sequence of events did not include immersion are more difficult to explain. One possibility is that the police accident report did not indicate immersion, which is why the FARS analyst did not record immersion, but an exploration of source documents is needed to provide a more definitive explanation for the difference.

Drowning fatalities by crash and vehicle characteristics

As expected, drowning fatalities are more common in some States than in others. In fact, the top five States accounted for slightly more than half of the total drowning deaths in 48 States and D.C. Table 3 contains the five States with the most recorded motor vehicle traffic deaths involving drowning.

Table 3.
States with the largest number of motor vehicle occupant traffic drowning fatalities

State	Fatalities
Florida	57
California	49
Texas	31
Louisiana	19
North Carolina	15

Note: No data for Hawaii and Wisconsin.

Generally Table 3 contains large coastal States. Given that these States are large and have many traffic accidents, another way to rank the States is by the percent of the traffic fatalities in the State that involve drowning. The results for the top five States by percent of fatalities involving drowning are included in Table 4.

Table 4.
States with the highest percent of motor vehicle occupant traffic fatalities involving drowning

State	Percent of Fatalities Involving Drowning
Idaho	3.5%
Vermont	2.9%
Alaska	2.8%
Louisiana	2.2%
Florida	2.1%

Note: No data for Hawaii and Wisconsin. Percent is based on fatalities with mortality data.

By the measure used in Table 4, Florida and Louisiana remain in the top five, but three different States also join the list. The top three States all have a relatively small number of total traffic fatalities, and their inclusion at the top of the list could be due to the percent being more sensitive to random variation in the number of drowning fatalities.

Table 5 indicates that the body types of the occupants' motor vehicles included a wide range of vehicles from passenger cars and pickups to motorcycles. However, the passenger vehicle category, which includes cars, utility vehicles, and most vans and pickups, accounted for 94 percent of the drowning fatalities and 94 percent of the vehicles involved in drowning. Given that drowning fatalities in non-passenger vehicles were relatively rare compared to passenger vehicles and because the crash dynamics and injury mechanisms are likely to be very different for non-passenger vehicles, the remainder of this paper focuses on the annual average of 361 drowning fatalities in passenger vehicle traffic crashes.

Table 5.
Motor vehicles where an occupant of the vehicle drowned

Vehicle Type	Annual Average Vehicles	Annual Average Drowning Fatalities
Passenger Vehicles		
Passenger car	181	206
Utility vehicle	51	65
Van	13	15
Pickup truck	72	75
Other Vehicles		
Bus	1	1
Large truck	7	7
Motorcycle	9	9
Other (ATV, etc.)	4	4
Unknown	2	2
TOTAL	339	384

Table 6 contains the passenger vehicle drowning fatalities categorized in terms of the number of vehicles involved in the crash and rollover occurrence. Table 7 contains information about the first harmful event for the single-vehicle crashes. Overall, 71 percent of the fatalities involved either a rollover or a collision with another motor vehicle: 59 percent in single-vehicle rollovers, 8 percent in a collision with another motor vehicle without a rollover, and another 4 percent in a collision with another motor vehicle and a rollover.

Table 6.
Passenger vehicle drowning fatalities
by number of vehicles in crash and rollover

Number of Vehicles	Rollover?	Annual Average Drowning Fatalities	Percent of Total
1	No	106	29%
1	Yes	214	59%
>1	No	29	8%
>1	Yes	12	4%
TOTAL		361	100%

Table 7.
Passenger vehicle drowning fatalities
in single vehicle crashes by rollover
and first harmful event

Rollover?	First Harmful Event	Annual Average Drowning Fatalities	Percent of Subtotal
Yes	Rollover	73	34%
Yes	Fixed Object	132	62%
Yes	Other	9	4%
Subtotal		214	100%
No	Immersion	26	24%
No	Fixed Object	73	69%
No	Other	7	7%
Subtotal		106	100%

Single-vehicle rollovers that result in drowning deaths began the crash sequence by running off the road or crossing the median or centerline 90 percent of the time. As indicated in Table 7, the first harmful event was a collision with a fixed object for 62 percent of the fatalities, most commonly a bridge rail, a guard rail, or a tree. In another 34 percent of the fatalities, the rollover was recorded as the first harmful event. Immersion was recorded as the most harmful event for 47 percent of the fatalities, and the rollover was recorded as the most harmful event in another 43 percent. Most of the remaining fatalities recorded a fixed object collision, most commonly a tree or bridge rail, as the most harmful event.

The second most common scenario in Table 6, accounting for 29 percent of the fatalities, was a single-vehicle crash without a rollover. Similar to the single-vehicle rollover, the first event in most of these fatalities (76%) was running off the road or crossing the median or center line. As indicated in Table 7, the first harmful event was a fixed object collision in 69 percent of the fatalities, most commonly with a tree, a guard rail or a curb. Immersion was recorded as the first harmful event in only 24 percent of the fatalities. The most harmful event was recorded as immersion in 69 percent of the fatalities, and the remaining fatalities were mostly in fixed object collisions, with trees alone accounting for 9 percent of the deaths.

The remaining 12 percent of the drowning fatalities occurred in more complicated situations involving more than one more vehicle. The first event in 67 percent of these fatalities was a collision with a vehicle in transport and another 25 percent involving crossing the median or centerline. In 90 percent of the fatalities, the collision with another motor vehicle in transport was the first harmful event, and the collision was the most harmful event in 69 percent of the deaths. The remaining most harmful events associated with the fatality were mostly immersion (19%) and rollover (7%).

While the previous tables addressed the circumstances surrounding drowning fatalities, they did not provide any information about the other occupants. Situations where the vehicle contained one occupant and the occupant drowned do not provide any information regarding other occupants. However, situations with more than one occupant provide variation for analysis because some occupants may have survived and some may have died of injuries other than drowning. Among vehicles with more than one occupant and at least one drowning death, about half (58%) of the vehicles had exactly two occupants. The maximum number of occupants in any one vehicle was 17. Table 8 gives counts of the total number of occupants, the total number of fatalities, and the total number of drowning fatalities for all passenger vehicles with at least one drowning fatality and at least two occupants.

Table 8.
Fatality outcome for occupants of passenger vehicles with at least one drowning fatality and at least two occupants

Number of Vehicles	Roll-over?	All Occu-pants	All Fatalities	Drowning Fatalities
1	No	149	101	44
1	Yes	376	221	101
>1	No	68	49	15
>1	Yes	26	16	7
TOTAL		619	387	167

Overall 37 percent of the occupants in passenger vehicles with at least one drowning fatality and at least two occupants survived the crash, which is calculated as the number of surviving occupants (619 minus 387 or 232) divided by the total number of occupants (619). The percent of surviving occupants ranged from 28 percent in multi-vehicle non-rollover crashes to 41 percent for single-vehicle rollovers. Table 8 also indicates that more than half of the fatalities (57%) in these vehicles were not drowning fatalities, which is calculated as the number of non-drowning fatalities (387 minus 167 or 220) divided by the total number of fatalities (387). The percent of fatalities that were not drowning fatalities ranged from 54 percent in single-vehicle rollovers to 69 percent for multi-vehicle non-rollover crashes.

Characteristics of drowning victims

While the preceding results concentrated on the crash and vehicle characteristics, this last section describes the characteristics of the annual average of 361 passenger vehicle drowning victims. In describing these traits, percentages are presented among those with known values. The characteristics of victim age, gender, seating position and ejection status were known for 96 percent or more of the cases. Police-reported restraint system use and alcohol involvement had smaller percentages of known values at 84 percent and 48 percent respectively.

Overall, 6 percent of the drowning victims were children 14 and younger, and 2.5 percent were children three and younger. Another 5 percent of the drowning victims were 75 years old or older. Males accounted for 65 percent of the victims. When seating position was known, 90 percent were in the front row. Among those with known ejection status, 14 percent were ejected: 10 percent totally and 4 percent partially ejected.

Table 9.
Key Characteristics of Drowning Victims among Fatalities with Known Values

Characteristic	Statistic
Age	6% Children 14 & under
Age	5% Adults 75 & over
Gender	65% Male
Seating Position	90% Front row
Ejection Status	10% Totally ejected
Police-reported restraint use	52% Not Using Any Restraint System
Police-reported alcohol use	44% Police-Reported Alcohol Use

Police-reported restraint system use was known for 84 percent of the drowning victims, and 52 percent of those with known restraint use were not using any restraint system. More than half the time, police-reported alcohol involvement for the occupant was either unknown or not stated on the police report. However, for the cases with known values, the police reported that alcohol was involved in 44 percent of the fatalities. Note that police-reported alcohol use only indicates the police officer's judgment as to whether alcohol was involved in the accident, and it is not based upon an alcohol test. It is only meant to provide an indication of the involvement of alcohol, and a more accurate estimate of alcohol involvement could be produced using model-based multiple imputation.

LIMITATIONS

As discussed previously, the linked FARS-MCoD file does not contain mortality data from two States (Hawaii and Wisconsin) and is missing one year of data from New Jersey. This missing mortality data means that the results represent 48 States and the District of Columbia rather than the entire United States. Also there is a small proportion of fatalities in each State (usually less than 5 percent) that do not link to the mortality data and thus drowning status is unknown.

In addition to missing data, there are two types of motor-vehicle related drowning deaths that are not considered in this paper. FARS contains only motor vehicle traffic accident fatalities as defined by the American National Standards Institute's "Manual on Classification of Motor Vehicle Traffic Accidents, Seventh Edition" (ANSI D16.1-2007). The two situations under which motor vehicle occupant drowning deaths may occur that would not be

included in FARS are nontraffic accidents and cataclysms.

Nontraffic accidents occur off of public roads in locations such as private roads, driveways, parking lots and undeveloped areas. One example of a nontraffic fatality involving drowning could occur at a private boat ramp where the vehicle accidently backs into the water and the occupant drowns. NHTSA recently started tracking nontraffic fatalities as part of its Not-in-Traffic Surveillance (NiTS). The NiTS 2007 system provided information about an estimated 545 occupant fatalities that occurred in nontraffic crashes such as single-vehicle crashes on private roads and two-vehicle crashes in parking facilities. Unfortunately, the system does not have any linked mortality data, which prevents a similar analysis to the one for traffic fatalities using FARS. Furthermore, while the file contains a most harmful event of immersion, the results previously presented in this paper indicate that this variable does not provide a good proxy for counting drowning deaths.

The second type not included in FARS is a drowning as the result of a cataclysm, such as flooding, that is not a motor vehicle accident fatality per ANSI definitions. For example, a motor vehicle swept away while a bridge it was crossing is washed out during a hurricane or flood would not qualify for FARS because the accident directly resulted from a cataclysm. Therefore cases of people who drowned in their vehicles during a flood or a hurricane would not be included in the statistics in this paper. However, accidents related to a cataclysm, but occurring after the cataclysm has ended, can be traffic accidents and could qualify for FARS. For example, a motor vehicle driven into water after a hurricane or flood because a bridge was washed out occur after the cataclysm has ended, and associated occupant drowning fatalities could qualify for FARS.

CONCLUSIONS

In spite of the limitations presented above, this paper provides answers to the two original research questions regarding how many drowning fatalities occur in motor vehicle traffic accidents and under what circumstances. Overall, drowning is associated with an annual average of 384 occupant fatalities in motor vehicle traffic accidents from 2004 through 2007 or about 1 percent of all occupant traffic fatalities during this period.

Focusing on the 361 passenger vehicle occupant drowning fatalities indicated that the most common crash scenario was a single-vehicle rollover. In fact, most (63%) drowning fatalities occurred in a vehicle that overturned when counting both single and multi-vehicle crashes. This statistic is important because rollovers are more dangerous crash scenarios than non-rollovers regardless of immersion status. Based upon passenger vehicle fatalities in the 2009 FARS and estimated passenger vehicle occupants from the National Automotive Sampling System-General Estimates System (NASS-GES), the estimated odds ratio of a fatality in a rollover versus a non-rollover is 29. Also, many drowning fatalities involved fixed object collisions or even collisions with another motor vehicle before entering the water. Therefore, most vehicles experienced some form of damage, and the occupants may have suffered injuries, before the immersion. Even when the drowning death involved a single vehicle that did not overturn, most fatalities (76%) occurred in vehicles that experienced a harmful event prior to immersion.

Overall, the victim was not using any form of restraint system 52 percent of the time. This statistic is important because restraint use is highly effective in preventing fatalities. In 2009, the use of seat belts in passenger vehicles saved an estimated 12,713 lives. Seat belts have saved over 72,000 lives during the 5-year period from 2005 through 2009. Given the effectiveness of seat belts in preventing fatalities in passenger vehicle crashes, the lack of restraint use greatly increases the odds of a fatality in a crash compared to using a seat belt. It is also likely that an unrestrained occupant in a rollover or collision with another motor vehicle would suffer injuries before the immersion.

While the paper provides information to address the original research questions, it leads to an additional query. It is not clear why many of the drowning deaths identified in the mortality data did not have immersion in the FARS sequence of events. Answering this question would require a special study of the FARS source documents to better understand how immersion is captured (or not captured) on police accident reports, and NCSA is currently exploring the feasibility of obtaining the police reports through FARS. The answer to this question, as well as drowning deaths in general, are important and deserving of further study.

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