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Preliminary Analysis of Roadway Accident Rates for Deaf and Hard-of-Hearing Drivers — Forensic Engineering Application

By Martin E. Gordon, PE (NAFE 699S) and Justin J. Pearson

Abstract

According to the World Health Organization, there are more than 360 million people worldwide with hearing loss. The National Highway Traffic Safety Administration (NHTSA) has reported that close to 30% of the United States population 65 years or older has significant hearing loss. The objective of this paper was to determine if deaf and hard-of-hearing drivers are more likely to be involved in motor vehicle accidents than hearing drivers. Data was extracted from the National Automotive Sampling System (NASS) and motor vehicle accident records from the Rochester Institute of Technology (RIT) and National Technical Institute for the Deaf (NTID) campuses. The results of the NASS data analysis indicate that deaf and hard-of-hearing drivers are one and a half to nine times as likely to be seriously injured or killed in a motor vehicle accident. Motor vehicle accident records from RIT and NTID suggest that deaf and hard-of-hearing drivers are approximately three times as likely to be involved in a motor vehicle accident as hearing individuals. Forensic engineers may be able to use this data to assist in forensic engineering analysis in cases where deaf or hard-of-hearing drivers are involved.

Keywords

Forensic engineering, traffic crash reconstruction, deaf drivers, hard-of-hearing drivers, accident rates

Introduction

The World Health Organization estimates that there are more than 360 million people worldwide with hearing loss, but there is no research entity dedicated to the study of road safety as it relates to deaf and hard-of-hearing (D/HH) locally, nationally or internationally. In fact, very little has been done worldwide to study deaf and hard-of-hearing drivers[1]. In the United States, as indicated in **Figure 1**, close to 30% of the population 65 years or older has significant hearing loss. A study commissioned by the National Highway Traffic Safety Administration (NHTSA) in 2005 recognized that very few studies of D/HH drivers have been conducted, and these studies had inconclusive results. The study points out that there is no evidence that warrants driving restrictions for the D/HH. In fact, the Americans with Disabilities Act of 1990 (ADA) and the Rehabilitation Act of 1973 (Rehabilitation Act) normally prohibit states from using risk assessment to prevent people with disabilities from driving. Instead, special driving tests are given to individuals to determine if they are a threat to public safety[2].

Currently, D/HH persons are able to obtain drivers licenses in all 50 states. However, in the 1920s, at least four states would not issue driving licenses to the D/HH[3]. The licensing requirements for the D/HH in New York State simply require a restriction indicating "hearing-aid" or "full-view mirror"[4].

By using the National Accident Sampling System (NASS)[5] and data from accidents occurring on the campus of the Rochester Institute of Technology (which includes the National Technical Institute for the Deaf), a potentially significant link between deafness and rates of injury, death, and accident involvement was discovered. This paper presents the *preliminary* findings from data mining these two sources. It is hoped that the paper will lead to a better understanding of what can be done when performing forensic engineering analysis of traffic accidents involving the D/HH. Additionally, it is hoped that further research may point to technologies that may be used to decrease driving risks for the D/HH and improve highway safety for all roadway users.

Martin E. Gordon, PE, Rochester Institute of Technology, 78 Lomb Memorial Drive, Rochester, NY 14623, (716) 913-2912, megite@rit.edu

Age Group	**% of Population that is Deaf**
3-17 years	1.8
18-34 years	3.4
35-44 years	6.3
45-54 years	10.3
55-64 years	15.4
65 years and older	29.1
Average for all ages	**8.6**

Figure 1
Deafness by age[2].

Data Mining

Two sources were used for data mining — the 2013 NASS GES database and a campus motor vehicle accident database between 2011 and 2015 for the Rochester Institute of Technology (RIT), which contains the National Technical Institute for the Deaf (NTID) on its suburban campus.

The 2013 NASS GES database was searched for a driver impairment type "deaf." For accidents sampled by NASS between 2008 and 2013, there were 36 cases involving a driver that had a "deaf" impairment. It is suspected that there are many more cases involving D/HH operators that do not show up with a "deaf" impairment flag. NASS administrators do not explain under what conditions "deaf" will be listed as impairment. If involved drivers were killed or seriously injured, it is not known how an investigator would know the hearing status of the operator.

The database from RIT and NTID was constructed to allow investigators an easy way to indicate whether a driver was hearing or deaf. The total campus population is around 17,000 students, of which approximately 5% to 6% are D/HH. The database included partial information from 384 accidents with complete information for only 319 of these accidents. D/HH drivers accounted for 49 of these accidents while hearing drivers were involved with 335 accidents. Only accidents with complete information (319 total) were used for statistical analyses. The accidents were of various severities, with most falling into the "minor" classification — not unexpected given a maximum campus speed limit of 35 mph and the many campus parking lots.

Data Analysis

NASS GES Data Source

Utilizing accident records for drivers from 2008-2013, the Rao-Scott Chi-Square test for association rejects the hypothesis of no association between hearing/deaf status and severity of injury with 0.02% significance (that is, 0.02% chance of observing data at least as extreme as found in the GES if there was no relation between deafness and injury severity).

This indicates that there is a relation between deafness and injury severity. Specifically, the probability of sustaining injuries of particular severities differs for deaf and hearing drivers. A visual overview of the injury distributions by impairment suggests that deaf drivers are more likely to experience injury in an accident, as can be seen in **Figure 2**.

Distinguishing only between drivers that did or did not experience definite injury — regardless of accident severity — a 95% odds ratio shows that hearing drivers are at least 1.4702 times (and at most 9.901 times) as likely to be uninjured in an accident as a deaf driver. This is the same as saying that deaf drivers are at least 0.101 and at most 0.6802 times as likely to be uninjured in an accident as hearing drivers. These general conclusions highlight the need for more research, since factors such as restraint usage, frontal impacts vs. rollovers, ejected vs. contained, could not be considered because of an insufficient quantity of deaf driver data sets containing these factors.

Data includes belted and unbelted drivers — future data mining may try to separate these groups to isolate deafness as a cause of higher injury rates. The authors are unaware whether hearing drivers or deaf drivers have different rates of seatbelt use. Data for hearing drivers came from the same source as for D/HH drivers, namely the NHTSA GES records. Driver impairment (such as "deaf" or "hard-of-hearing" and "none") was recorded, so it was possible to distinguish between groups for analysis — given the caveats discussed in the previous section.

Cases where injury status was unknown — and cases where the driver had died prior to the accident — were removed as unsuitable. Also disregarded for both hearing and D/HH drivers were cases where injury proved fatal, as none of the D/HH records collected were of fatal accidents. "Possibly injured" was treated as "uninjured" because it was not a definitive

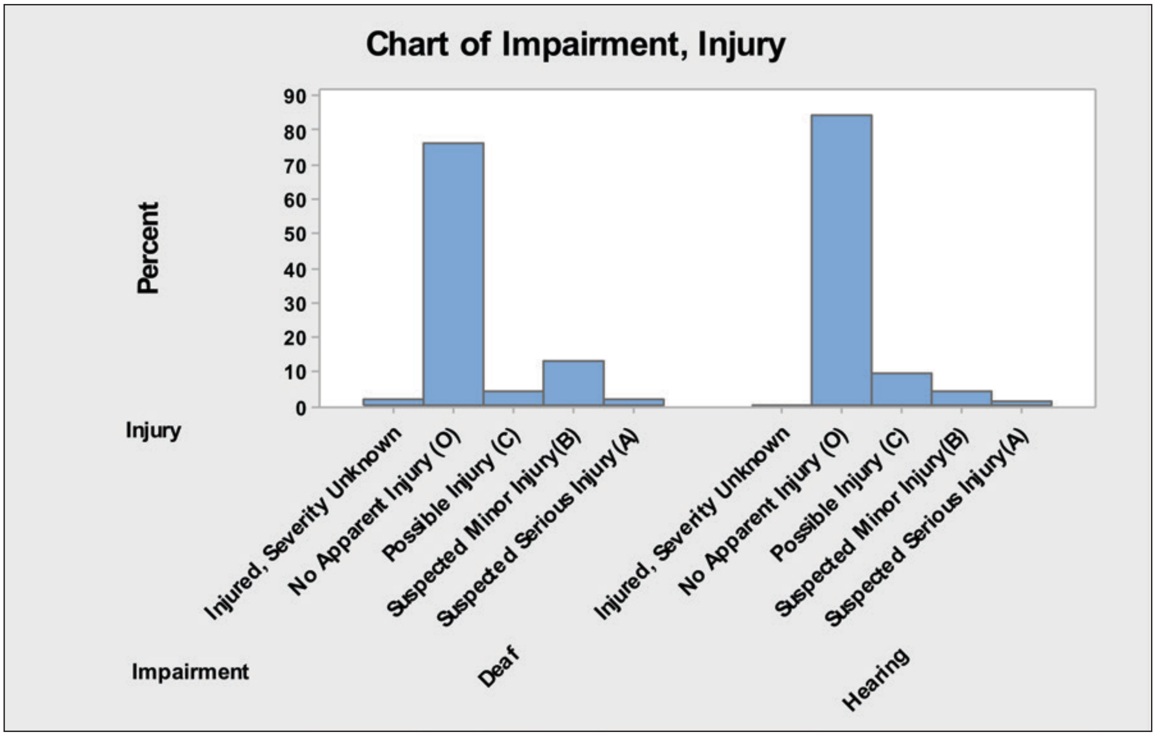

Figure 2
Injury percent by deaf or hearing.

injury (and, given the nature of the inquiry, it would be better to conservatively underestimate likelihood of injury than risk overstating it). All other categories were treated as "injured," since the GES records use the KABCO injury scale, which classifies suspected injuries as definite injuries of unknown severity — not very helpful for distinguishing severity of injury, but sufficient to determine that the driver was injured. The NHTSA GES does include police-reported injuries in its records on the person or persons involved with the accident (the "person" dataset). From the *Analytics User Manual 1988-2014*:[5]

> *Person – (1988-current): This data file contains information describing all persons involved in the crash including motorists (i.e., drivers and passengers of in-transport motor vehicles) and non-motorists (e.g., pedestrians and pedal cyclists). It provides information such as age, sex, and vehicle occupant restraint use and injury severity.*

It should be noted that NHTSA changed how it tracked just about every factor multiple times over the period examined. Each year's data was reformatted to a common 2013 scheme.

The GES records provided weights to represent a national sample for each year, and analysis was done on the weighted data. This project had data covering 2000 to 2013, but only the data from 2008 to 2013 was used in this initial study.

RIT/NTID Data Source

The preliminary campus data gives yearly information on the deaf and hearing student populations as well as counts of the on-campus motor vehicle accidents for both. This can be used to compare accident rates between deaf and hearing students.

Performing the Breslow-Day test for interaction between the year and the relation between deafness and accidents, the authors find that the p-value is greater than 0.05. Therefore, the authors fail to reject the hypothesis of no interaction. As a result, the accident data over the years 2011 to 2015 was simply pooled. A contingency table that compares accident frequency by deaf and hearing population can be found in **Figure 3**. The "accident" column represents people that were involved in an accident. The "no accident" column was calculated by subtracting the "accident" column from the total population. A contingency table that compares accident percent for the same populations is shown in **Figure 4**.

The Pearson Chi-Square test for association has a p-value less than 0.05, so the authors reject the null

Population Group	Accident	No Accident	Total
Deaf	34	2,577	2,611
Hearing	285	47,159	47,444
13 Total	*319*	*49,736*	*50,055*

Figure 3
Frequency of accident by population.

Population Group	Accident	No Accident
Deaf	1.3%	98.7%
Hearing	0.6%	99.4%

Figure 4
Percent of accidents by population.

hypothesis of no association and conclude that deafness is related to likelihood of being in an accident.

Figure 5 presents an odds ratio and relative risk for deaf drivers compared to their hearing peers. Looking at the 95% confidence interval for the odds ratio, the authors see that the odds of being in an accident on campus are at least 1.5265 and at most 3.1224 times greater for deaf drivers than for hearing drivers.

Statistic	Value	95% Confidence Low Limit	95% Confidence High Limit
Odds Ratio	2.1832	1.5265	3.1224
Relative Risk	2.1677	1.5224	3.0867

Figure 5
Odds ratio and relative risk — deaf vs. hearing drivers.

Application to Forensic Engineering

Almost any person who has contact with the deaf or hard-of-hearing community has a story related to a deaf driver — usually one that involves an accident or near-accident. In the primary authors' experience, most stories involve a driver using sign language to communicate with passengers while operating a motor vehicle. Many of these stories provide anecdotal evidence that would suggest that deaf drivers are more likely to be involved in motor vehicle accidents. Obviously, anecdotal stories and evidence are of limited value in a forensic engineering analysis. It is because of this lack of hard evidence that this initial quantitative analysis of accident data involving deaf and hard-of-hearing drivers was undertaken. Prior to this study, no study (to the authors' knowledge) had been done to quantitatively assess whether deaf and hard-of-hearing drivers are indeed at a greater risk for accidents than their hearing driver peers.

Forensic engineers should determine whether a deaf or hard-of-hearing person was an operator of one of the involved vehicles in any motor vehicle accident. If a motor vehicle accident is determined to involve a deaf or hard-of-hearing driver, a forensic engineer might want to investigate whether there were passengers in the vehicle along with the deaf driver. The reason for this is the fact that signing requires the use of at least one hand and a portion of the visual attention of the driver. Although not proven at this point, a person may draw a parallel between signing while driving and texting while driving. It is hoped that future data mining and research will determine whether this similarity is in fact true.

One of the major issues involved in a study of this type is the fact that the deaf and hard-of-hearing community is very protective of their driving rights. As mentioned earlier, it was not too long ago that there were states that prohibited deaf drivers from obtaining a driver's license. The suggestion that the deaf community as a whole is subpar in the operation of motor vehicles goes counter to the notion that a deaf and hard-of-hearing person is just as capable a driver as any hearing person. In fact, during multiple casual discussions with deaf individuals regarding driving, there were many instances in which deaf individuals claimed that they were better drivers than their hearing counterparts because of their alleged superiority in visual awareness[6]. While this may be true, it can be argued that part of that superior visual awareness is being used up while one is communicating using sign language.

Future Work

Any ethical engineer has a duty to warn if a significant hazard is discovered in the line of his or her engineering work. It is partially with this in mind that this paper was developed for the forensic engineering community. Furthermore, if an engineer possesses adequate resources, the engineer could begin exploring a solution to the hazard or strive to better understand the hazard. For the hazard exposed in this paper, an engineer might explore technologies that could mitigate the hazard. For example, potentially useful accident-avoidance technologies may be currently available in many new automobiles that could prove useful in reducing the risk to deaf drivers[7].

In addition, it is hoped that by further analyzing the data, a better understanding can be created regarding why it is that deaf drivers are more likely to be in a motor vehicle accident and more likely to be killed or injured in that accident. The issue comparing signing while driving to texting while driving is one example of an area where more research needs to be done. Further research also needs to be completed on a more representative dataset that expands beyond the reaches of the RIT/NTID campus. Only in this way could a direct link between deafness and a higher likelihood for involvement in a motor vehicle accident be proven or disproven for society at large.

Finally, the issues exposed in this paper are not yet well understood. Is it the fact of being deaf or hard-of-hearing that creates an increased risk, or is it the use of a visual sign language that causes an increased risk? Or, perhaps the danger is created through a multitude of unknown mechanisms. Perhaps studies could be performed using driving simulators or closed driving courses to evaluate numerous hypotheses.

Conclusion

Statistical analysis of certain data shows that deaf and hard-of-hearing drivers on the campus of RIT/NTID are 1.5 to 3.1 times more likely to be involved in a campus motor vehicle accident. Statistical analysis of certain national data shows that a hearing driver is approximately 1.5 to 10 times more likely to remain uninjured in an accident as compared to a deaf or hard-of-hearing driver. It is recognized that the data sets did not completely address D/HH drivers in a robust manner, and further data mining may lead to differing results. There may be some similarity between signing while driving and texting while driving. Forensic engineers should attempt to determine whether the involved drivers in a motor vehicle accident were deaf or hard-of-hearing.

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