

Driver's Traffic Fatality and How Could We Survive

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Introduction

Every day, nearly 100 people die from vehicle-related accidents. From 2010 to 2015, there are 2912 people died in 2699 fatal traffic accidents in Maryland. Basically, traffic accidents are unavoidable, however, it is possible that we face the fact and protect ourselves. Thus, we would like to know what factors could have impact on a severe accident which might cause fatality, especially for a driver. And also, if a possibly fatal accident happens, do we have any chance to prolong our lives, and even, save our lives.

Fatal risks include personal characters (age, sex, position)², time factors (season, time of the day), driving behaviours (drunk, safety measurement) and environmental description (location)³. Each of these factors could be a potential threat to our safety and they could also work interactively. Here we fit a logistic model² to figure out their causality and relationship.

Once a serious traffic accident happens, the response and rescue from hospitals would be the last hope to save the live. Response time and arriving time at the scene⁴ would be the first concern to construct a survival model.

Data Description

Data was compiled using the 2010-2015 Fatality Analysis Reporting System (FARS) data¹. We use Maryland fatality data extracted from the big data set to analyze risks in fatal traffic accidents within this state. Missing data related with age, death time was eliminated from analysis. Due to large volume of missing data with medical service time records, thus, we applied survival analysis on nationwide dataset and used available medical service time variables.

Statistical Methods

1. Logistic Model

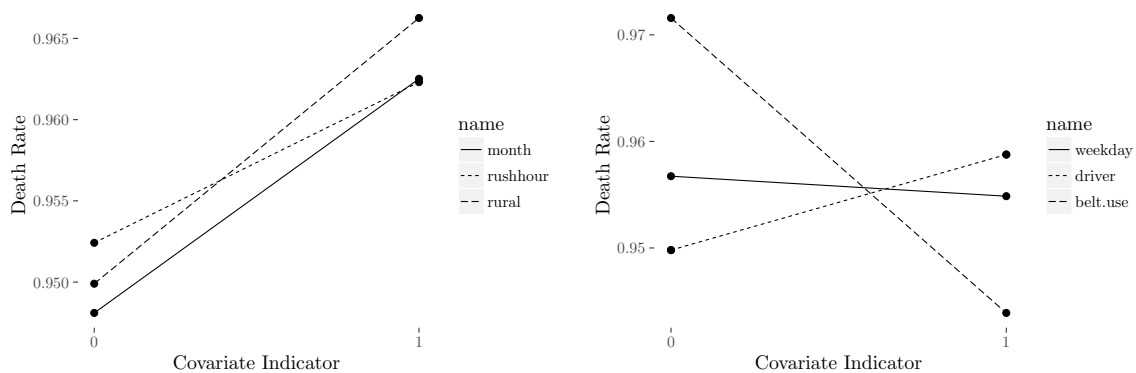


Figure 1: Possible Risk

We made plots to show the effect of possible risk factors. Drivers are relatively to be threatened by death among all accident-relevant types of people(passenger, pedestrian, Bicyclist, other). Basically, death rate is higher when the accident is happened at rush hour (7-10 am, 4-7pm) on weekdays between May to October.

Accidents happened at rural area are likely to have dead cases compared with that at urban area. And apparently, using seat belt could decrease the death probability. Based on our findings, we would like to consider cases only include over-16-year individuals to confirm the possibility of being a driver.

Logistic model is favorable when analyzing binary data. Based on our preliminary data analysis, we could construct a simple logistic model.

$$\begin{aligned} \text{logit}(P(\text{Death} = 1)) = & \beta_0 + \beta_1 \text{sex} + \beta_2 \text{age} + \beta_3 \text{weekday} + \beta_4 \text{month} + \beta_5 \text{rushhour} + \beta_6 \text{rural} \\ & + \beta_7 \text{is.driver} + \beta_8 \text{belt.use} \end{aligned}$$

With plotting the relationship between age and fatality (supplemental), we find that the continuous variable age could be divided into three categories. Natural spline was used on age factor in order to allow a smooth relationship between age and outcome. By cross validation, we get the AUC for simple model is 0.635.

Then we add more interactive items to the GLM model. The fatality rate in an accident would be higher is the driver is drunk. And apparently, seat belt use is highly related with driver's safety. According to these facts, our updated logistic model is given as:

$$\begin{aligned} \text{logit}(P(\text{Death} = 1)) = & \beta_0 + \beta_1 \text{sex} + \beta_2 \text{age} + \beta_3 \text{weekday} + \beta_4 \text{month} + \beta_5 \text{rushhour} + \beta_6 \text{rural} \\ & + \beta_7 \text{is.driver} + \beta_8 \text{belt.use} + \beta_9 \text{belt.use} * \text{is.driver} \\ & + \beta_{10} \text{drunk} * \text{is.driver} \end{aligned}$$

In this model, we get AUC=0.662 with cross validation. The table shows our estimation of model coefficients.

predictor	$\hat{\beta}$	Std (with)
Is_driver	0.683	0.306
Rural	0.409	0.159
Rush Hour	1.074	0.404
Weekday	0.067	0.164
Mid-Month	0.324	0.14
Is_driver: Belt Use	-0.3	0.338
Rush Hour:Weekday	-1.08	0.442

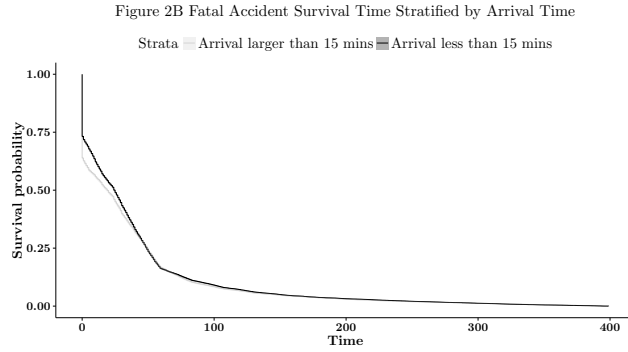
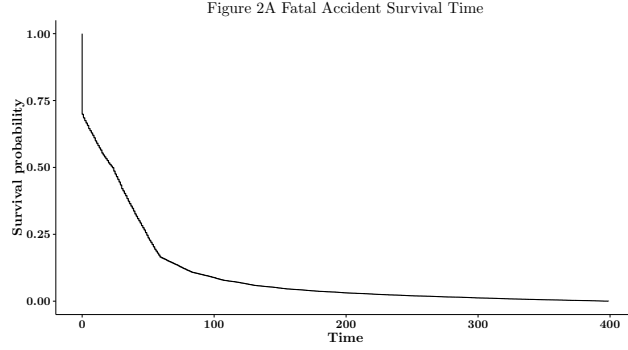
Thus, we conclude that compared with other person type involved in a fatal accident, the odds ratio of a driver's death is multiplied by 1.98 (1.087,3.607). Odds ratio of death at rural area is 1.505 (1.102,2.056) of that at urban area. During everyday's rush hour, odds ratio is increased by 1.927 (0.326,5.461). From the mid-Spring to mid-Autumn, odds ratio of death is 1.383 (1.051,1.819) of other seasons in a year. If a driver uses seat belt, the risk of death would be decreased by 0.259 (0.618,-0.437).

Actually, the analysis is incomplete to some extent. First of all, it is better to include all accident data over 5 years in Maryland to make inference about fatality rate, probably with imputation method. Secondly, more factors could be included in the model to improve the accuracy of the predictive model.

2. Survival Analysis

A fatal accident could always happen no matter how we try to avoid it. In this situation, it is critical prolong the survival time or even save lives. It is believed that medical response time could affect survival time after traffic accidents⁴.

Notification time is the time we used to inform the emergency medical service after the accident happens. The time duration that emergency medical service arrived on the crash scene is called arrival time. Both of them could be calculated based on FARS data.



Lag time is the period between the time of the crash and this person's time of death. Figure 2A shows the fatality rate over time. This fatality curve, or survival probability curve over time, $S(t)$, indicates that approximately 0.774 of fatalities occurring within 6 hours occurred within 100 minutes of the crash (including 0.331 instant deaths before time = 10). Then, we plot fatality curve for stratified dataset based on notification time and arrival time. And it turns out that arrival time has a more significant effect on fatality rate. Figure 2B indicates that early arrival time (arrival time < 10) could help with decrease the proportion of instant death.

Based on this, we construct a Cox Proportional Hazard Model (Cox-PHM). Actually, emergency medical service often based on the location of the crash scene. Thus, we include rural indicator in our model:

$$h(t) = h_0 \exp(\beta_1 \text{Arrival} + \beta_2 \text{Location})$$

The model included two factors treated as binary variables: arrival time (later than 10 minutes versus earlier arrival) and crash location (rural versus urban)⁴. From the results, we conclude that later arrival time could carry a 2.14% (0.38%, 3.92%) relatively higher fatality hazard than earlier group. Moreover, hazard rate for urban area is 0.8439 (0.8295, 0.8586) of that for rural areas, which means longer survival time in cities.

Now we could say that earlier arrival of emergency service helps with increase of survival probability since most of the fatal case happens very quickly. However, this simple survival analysis could not include all of the information to estimate the survival rate. And unfortunately, the time of death after injury and emergency service arrival may be inconsistently recorded. A thorough analysis of the data would be required if we want a more precise result.

Conclusion

As for fatal traffic cases, many factors would influence the death of a person involved. Generally speaking, drivers in the accident are the most vulnerable people and the situation could be even worse if they don't wear a seat belt. The fatality rate would increase when roads get crowded, such as rush hour, week day, and relatively warm seasons. Based on that, drivers should be more careful when there is a relatively busy traffic on the road. And also, in-time emergency medical service could help to decrease the probability of early mortality and accordingly, create chances to save lives.

Reference

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- [2]. Lui, Kung-Jong, et al. "An application of a conditional logistic regression to study the effects of safety belts, principal impact points, and car weights on drivers' fatalities." *Journal of Safety Research* 19.4 (1989): 197-203.
- [3]. Clark, David E., and Brad M. Cushing. "Rural and urban traffic fatalities, vehicle miles, and population density." *Accident Analysis & Prevention* 36.6 (2004): 967-972.
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