


# Statistical Analysis of Navy Personal Motor Vehicle Fatalities

Geoffrey S. Shaw • Michael D. Bowes • Kletus S. Lawler

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A handwritten signature in black ink that reads "Alan J. Marcus". The signature is written in a cursive style with a horizontal line at the end.

Alan J. Marcus, Director  
Infrastructure Resource and Management Team  
Resource Analysis Division

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# Summary

## Background

In 2003, CNA did a study [1] for the U.S. Marine Corps that examined off-duty fatalities. In that study, we identified individual risk factors and career events that affect the probability of a fatal accident. In this paper, we take a similar approach, but consider Navy personnel, examining the risk factors related to vehicle-related fatalities among enlisted sailors. We consider all vehicle fatalities except those involving military operations. We look separately at motorcycle accidents, an area of interest because of the growing numbers of motorcycle deaths among military personnel. The objective of the study is to determine, in an analytically sound manner, the factors that explain these vehicle fatality rates. The hope is that this will aid in selecting tools and interventions to reduce deaths.

## Study approach

- *Data.* We built a data set characterizing individual sailors and vehicle fatalities that occurred between October 1999 and September 2007. Individual personnel records are the principal source of data, although we incorporate additional information from safety records.
- *Analysis.* We undertook a statistical analysis to estimate the risk of a vehicle-related fatality. In the analysis, we look at the relationship of various individual characteristics and career events to risk. We use an approach referred to as survival or hazard rate analysis [2, 3], a technique often used to evaluate the effectiveness of medical treatments. In addition, we provide a summary graphical analysis of the Navy vehicle fatality data, with comparisons against equivalent civilian data. We also explore some of the changes in risk that have occurred over this time period.

## Summary of study findings

Our primary interest is in factors that explain average fatality rates over the 8-year period. Among the interesting findings are the following:

- *Early career.* There is a period of high risk for automobile fatalities that begins in the second half of the first year of service.
- *Paygrade and age.* Individuals aged 21 through 24 in the E4 to E6 paygrades face the highest risk of motorcycle fatality. Individuals in paygrades E1 to E6 (beyond their first 6 months of service and below the age of 25) face more than three times higher risk of automobile fatality than sailors in E7 to E9 paygrades. The risk of automobile fatality generally declines with age.
- *Occupational fields.* Individuals in construction, ship engineering, and aircraft maintenance jobs face the highest risk of motorcycle fatality. Those in construction face the highest risk of automobile fatality.
- *Location.* Automobile fatality risks are highest in the Northeast, Southeast, and Northwest regions (defined in appendix A). The risk of a motorcycle fatality has been highest on average for sailors stationed overseas—but overseas fatalities have come down in recent years. Motorcycle risks are also relatively high in the Southwest.
- *Enlistment waivers.* Individuals who enlist with waivers for traffic or other serious offenses are more likely to be in fatal automobile accidents than those with no enlistment waiver. Individuals who enlist with a drug or alcohol waiver face more than twice the risk of a motorcycle fatality as compared to those with no waiver.
- *Post-deployment.* There is a high risk for automobile fatalities during the nine months following a return from deployment, with peak risk between 6 to 9 months after deployment. There is no obvious post-deployment effect on motorcycle fatalities.

- *Promotions and demotions.* Individuals who were demoted within the last 3 months have three times the risk of a fatal motorcycle accident than others.
- *Race and ethnicity.* Blacks are 50 percent more likely to have a fatal accident than other racial or ethnic groups.
- *Gender.* Males are twice as likely to have a fatal automobile accident compared with females. Only one fatal motorcycle accident has involved a female sailor.
- *Education.* Individuals who did not graduate from high school (i.e., high school equivalency or less) have three times the risk of motorcycle fatality as those with high school degrees.
- *Time of year.* The risk of a motorcycle accident is more than twice as high in the summer than in the winter.
- *Time of day.* Automobile fatalities peak in the early morning hours (0100 to 0300). Motorcycle fatalities peak in late afternoon and evening (1500 to 2100).

## Organization of the report

The study is divided into two parts. In the first section, we discuss data sources and provide a graphical overview of Navy vehicle fatality statistics. In the second, we describe our statistical analysis and the results of that analysis. In the statistical analysis, we separately evaluate risk factors for (a) all vehicle deaths, (b) motorcycle deaths, and (c) automobile deaths. We also investigate whether some of the risk factors have changed over time.

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# Overview of the data on Navy vehicle deaths

In this section, we present information on our data sources. In addition, we provide summary graphical information on Navy vehicle-related deaths. The information presented here provides a general sense of trends and introduces issues of concern that are explored more fully in the later statistical analyses.

## Data sources

The goal of the study is to examine how career events and personal characteristics affect Navy fatality rates. To do this, we needed a data set with information on fatalities and the other factors of interest. Furthermore, in order to have a comparative baseline against which to evaluate apparent risk factors we needed data on all sailors, not just those involved in fatal accidents. However, because there is no one source for such data, we built the necessary data set by combining information from personnel records with information on vehicle accidents provided by the Naval Safety Center.

The Enlisted Master Records (EMR) and Officer Master Tapes (OMT) provided us with information on Navy personnel serving on active duty (including reserves on active status). From the EMR and OMT records we drew quarterly data identifying demographic characteristics (e.g., age, sex, race, and marital status) and career information (e.g., occupation, rank, and current command). We determined deployment status based on ship or squadron employment histories. For information on waivers (for traffic, drug/alcohol, or criminal offenses) that are granted during enlistment, we drew on Naval Recruiting Command records retained at CNA.

Although the personnel records do indicate date of death, the information provided is not sufficient to reliably identify vehicle fatalities. Instead, we used Naval Safety Center records to identify fatalities. The Naval Safety Center data gave us information on each vehicle accident, including date, time, and type of vehicle involved. We merged

the two data sets, using social security numbers (SSN) to the extent possible. Unfortunately, the Safety Center did not retain SSNs until FY 2004, and, in later years, they are often missing or inaccurate. However, we found sufficient personal information in the Safety Center files (initials, date of mishap, age, sex, rank, occupation) to reliably match most fatalities to specific individuals in the personnel files.<sup>1</sup> The resulting data set covers fiscal years (FYs) 2000 to 2007, during which time there were 513 vehicle-related deaths, with 146 motorcycle deaths. We had hoped to consider both fatal and non-fatal accidents in this study, but found it impossible to reliably identify individuals involved in non-fatal accidents.

Our later statistical analysis uses quarterly data on enlisted personnel, with data for those involved in fatal accidents and data for a randomly drawn sample (5 percent) of other sailors active at any time during FYs 2000 to 2007. The sample is scaled up in the statistical analysis so as to represent the overall population. The sample was taken to reduce the size of our working data set. There would otherwise have been many millions of quarterly observations. This sample was determined to be large enough to provide us with accurate estimates of relative risk and fatality rates.

## Summary statistics on vehicle deaths

### Annual trends in vehicle fatalities and fatality rates

Figure 1 shows annual trends in vehicle fatalities and fatality rates per hundred thousand.<sup>2</sup> Since 2000, the overall vehicle fatality rate for the Navy has remained relatively constant at around 15 to 20 fatalities per hundred thousand sailors per year, with perhaps a slight increase over time. The total number of Navy fatalities for FY 2008 became

- 
1. There were nine enlisted fatalities in the Safety Center data we could not link to Navy personnel records.
  2. All fatality rates are per hundred thousand sailors in the category identified on the charts (e.g., FY, age, paygrade, region, occupation). Unless the FY is specifically identified, fatality rates shown are average annual rates over the entire time period 2000 to 2007.

available very recently. Although we were unable to use the FY 2008 data in our statistical analysis, we do report the numbers here.

Simply comparing Navy fatality rates to the overall civilian rate would be misleading, since demographically the Navy population is predominately made up of young-adult males. Instead, we make the comparison to an equivalent civilian population of the same age and gender distribution as the Navy.<sup>3</sup> As seen in figure 1, Navy vehicle fatality rates are substantially below those for this equivalent civilian population.

Figure 1. Trends in Navy vehicle-related fatalities

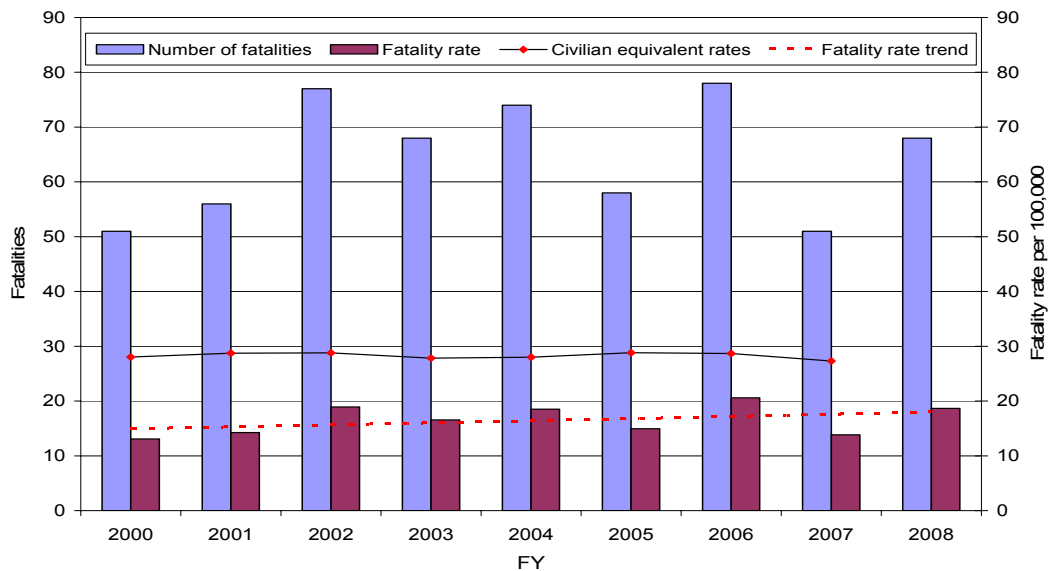
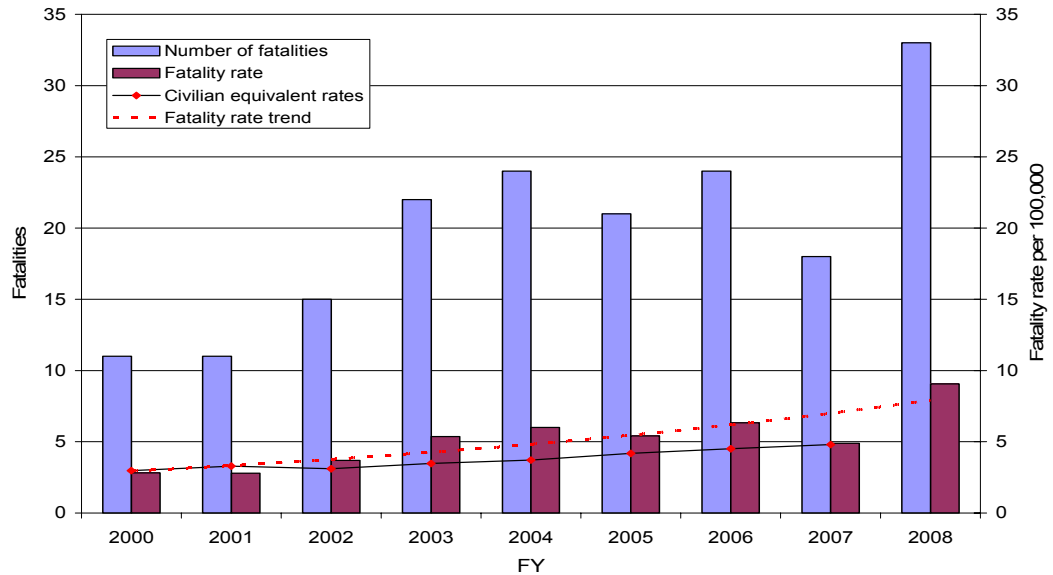


Figure 2 shows the trends in motorcycle fatalities. Motorcycle fatality rates have been increasing for both civilians and the Navy. In FY 2000, the Navy motorcycle fatality rate was about three per hundred thousand. The rate for an equivalent civilian population was essentially the same. Since then, the Navy motorcycle fatality rate has grown at 11 percent per year, faster than the 7 percent growth in the fatality rate for an equivalent civilian population. The increase in motorcycle fatality rates offsets a decline in automobile fatality rates, such that the

3. Civilian mishap rates by age and gender are derived using fatality data from the NHSTA Fatality Analysis Reporting System and U.S. Census Bureau population estimates. These rates, by age and gender, are then applied to the Navy population numbers to calculate the civilian equivalents.

overall vehicle fatality rates have remained essentially constant. It would be interesting to determine the extent to which the increases in motorcycle fatality rates are driven by growth in ownership or by deficiencies in driving behavior and training. Unfortunately, information on Navy motorcycle ownership is limited.

Figure 2. Trends in Navy motorcycle fatalities



### Vehicle fatality rates by age

As shown in figure 3, the likelihood of an automobile-related death has a strong relation to age. Automobile fatality rates are highest for individuals aged 19 to 21, then decline steadily as the group ages. The Navy's death rates are substantially lower than civilian equivalent rates at every age, but the pattern of decline with respect to age is similar.<sup>4</sup> Had the Navy simply matched civilian rates, they might have seen almost twice as many deaths in total.

For motorcycle fatalities (figure 4), the trends look very different. The Navy motorcycle fatality rate generally increases with age into the mid-twenties and then remains fairly constant into the thirties. The equivalent civilian rates also show only modest declines with age. However,

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4. Fatality rates are average annual rates per 100,000 individuals by age. The civilian equivalent rates reflect the Navy gender mix at each age.

civilian motorcycle fatality rates are generally lower than the Navy rates, especially for individuals in their mid-twenties.

Figure 3. Navy non-motorcycle vehicle fatality rates by age

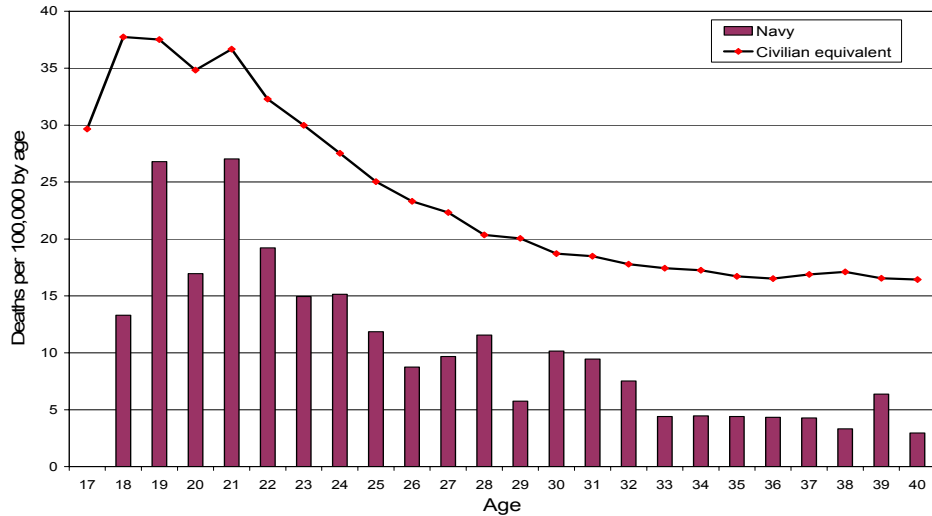
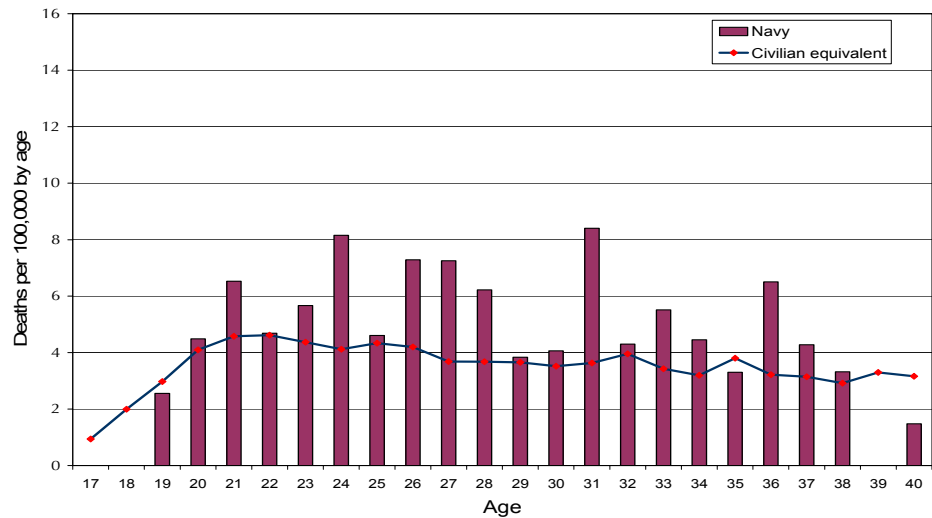


Figure 4. Navy motorcycle fatality rates by age



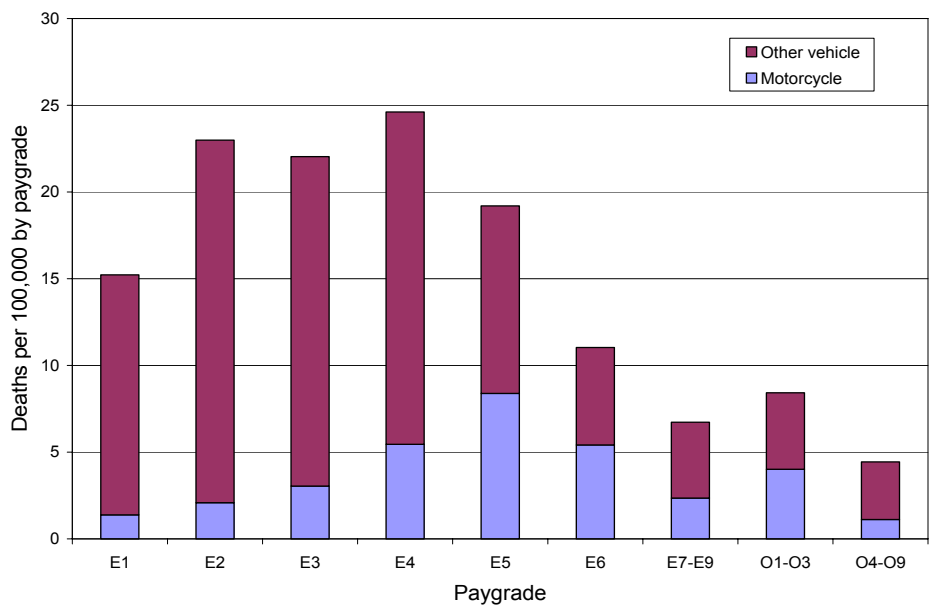
## Vehicle fatality rates by paygrade

Fatality rates by paygrade (figure 5) vary in a manner similar to that seen for age. Rates are based on the population within each paygrade. Overall vehicle fatality rates peak at the E4 paygrade. Non-motorcycle fatality rates peak at the E2 paygrade and then decline with enlisted rank. In contrast, motorcycle fatalities peak at the more

senior E5 paygrade. The low fatality rates observed for the E1 grade no doubt reflect the limited driving privileges for new sailors. The fatality rates for junior officers (O1–O3) exceed those for senior enlisted (E7–E9). Although that is perhaps reason for concern, it must be noted that the absolute number of deaths among the officers is small.

The fatality rate trend for automobile (non-motorcycle) accidents by paygrade seems easy to explain. Servicemen in higher paygrades are typically older, more experienced drivers and thus less likely to have accidents. The motorcycle fatality rate is harder to explain. It could be that sailors who have achieved the E5 paygrade are more able to afford a motorcycle as a second vehicle.

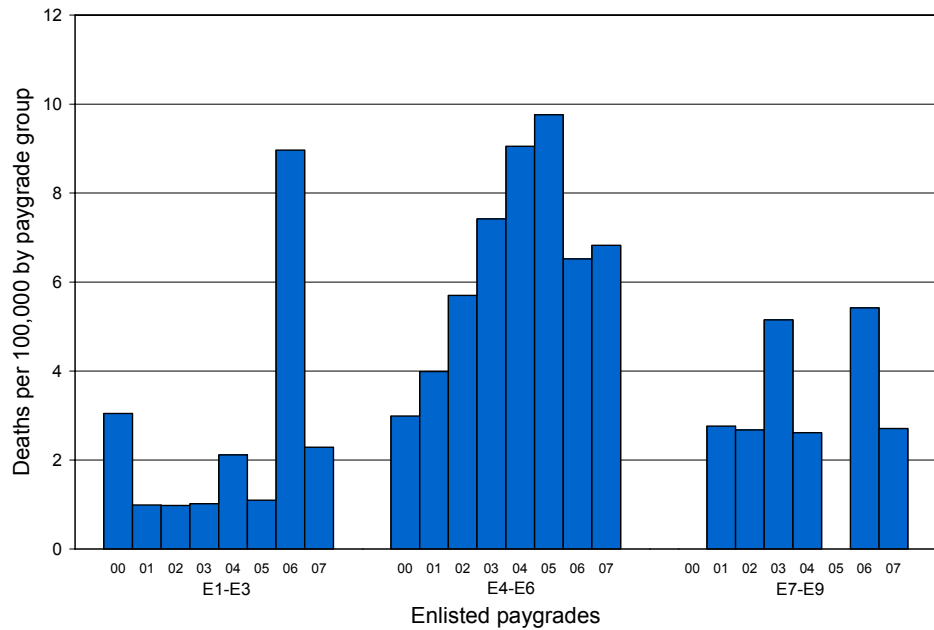
Figure 5. Navy vehicle fatality rates by paygrade



### Trends in fatality rates by paygrade

In figure 6, we show the trends over time in motorcycle fatality rates by paygrade. Motorcycle fatality rates have been increasing at 12 percent a year for the mid-level (E4 to E6) paygrades. The same steady increase in fatality rate is not as apparent for other paygrade groups. Hopefully the FY 2006 spike for the E1 to E3 group was just an aberration.

Figure 6. Trends in Navy motorcycle fatality rates by paygrade



## Navy vehicle fatality rates by time of day

Figure 7 shows average automobile fatality rates by time of day for the Navy and an equivalent civilian population. Similarly, figure 8 shows the motorcycle fatality rates by time of day.

Figure 7. Navy non-motorcycle fatality rates by time of day

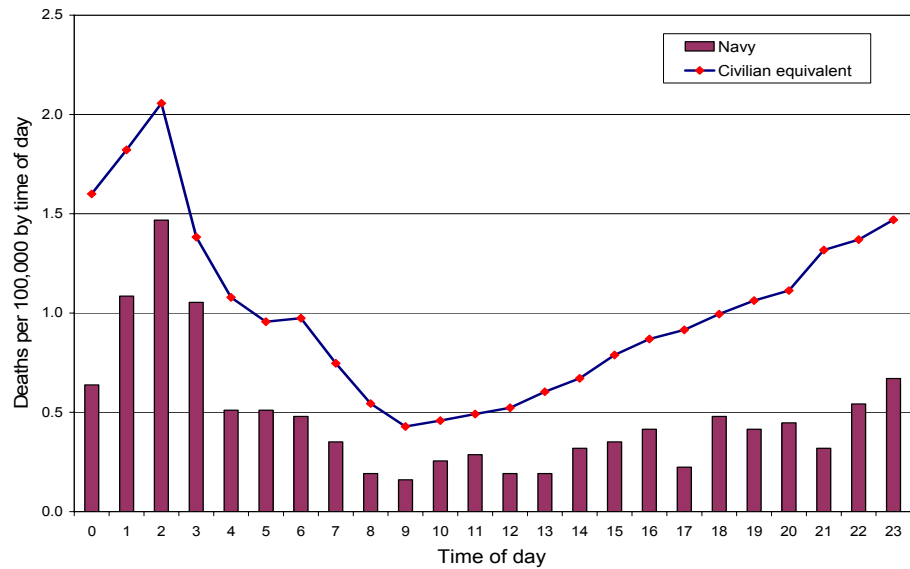
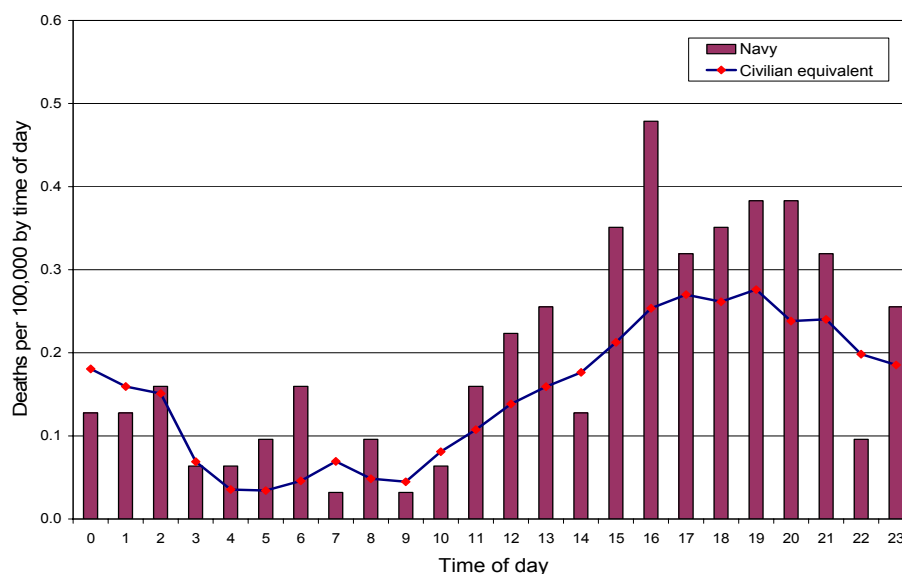


Figure 8. Navy motorcycle fatality rates by time of day



The Navy’s automobile fatality rates are below those for a similar civilian population at every time of day. The relative difference between the two populations does not change much over the day, until the evening hours. After 1600, the fatality rate for the Navy stays fairly constant through the evening hours, while the rate for the civilian equivalent population increases steadily. Overall vehicle fatality rates peak at 0200. The high fatality rates in early morning hours may be related to fatigue and alcohol consumption.

The general distribution of motorcycle fatalities by time of day is similar for the Navy and the equivalent civilian population (as seen in figure 8). Fatalities peak in the afternoon and early evening hours. That is also when Navy fatality rates most often exceed the equivalent civilian rates. The overall pattern of motorcycle deaths, with few morning rush hour deaths, seems most consistent with recreational use.

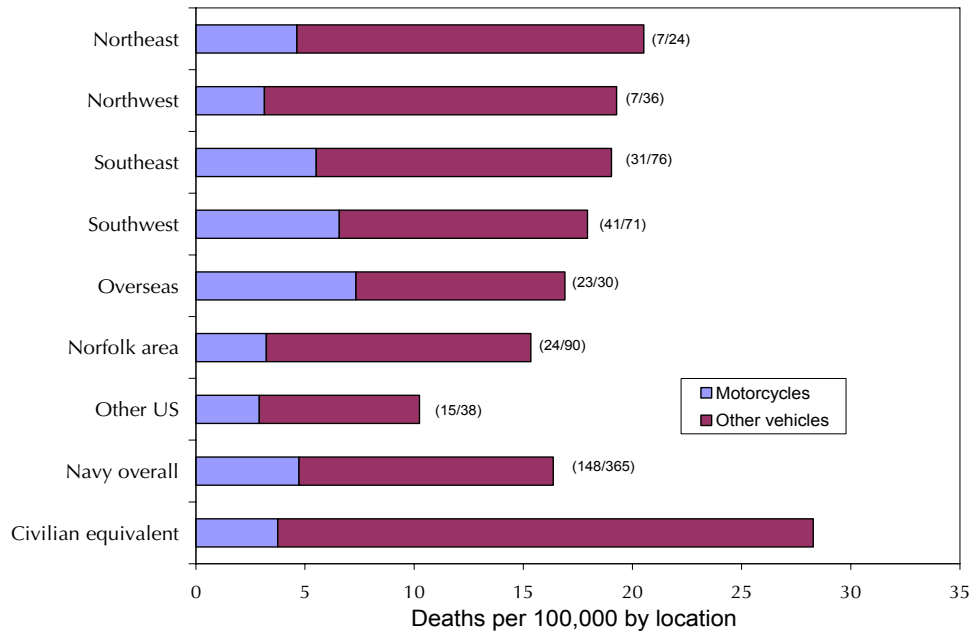
### Vehicle fatality rates by location

Figure 9 shows vehicle fatality rates by command location, for regions of Navy concentration (defined in appendix A). The figure shows both motorcycle and other-vehicle fatality rates. These are average annual fatality rates over the entire time period. The numbers in pa-



parentheses indicate the total numbers of deaths (motorcycle/other vehicle) observed over the 8-year period. Not surprisingly, the regions with the greatest number of fatalities are the Norfolk area (with 114 fatalities), Southwest region (with 112 fatalities), and the Southeast region (with 107 fatalities) where the Navy has the most personnel. Overall vehicle fatality rates are highest in the Northeast, Northwest, and Southeast.

Figure 9. Vehicle fatality rates by location

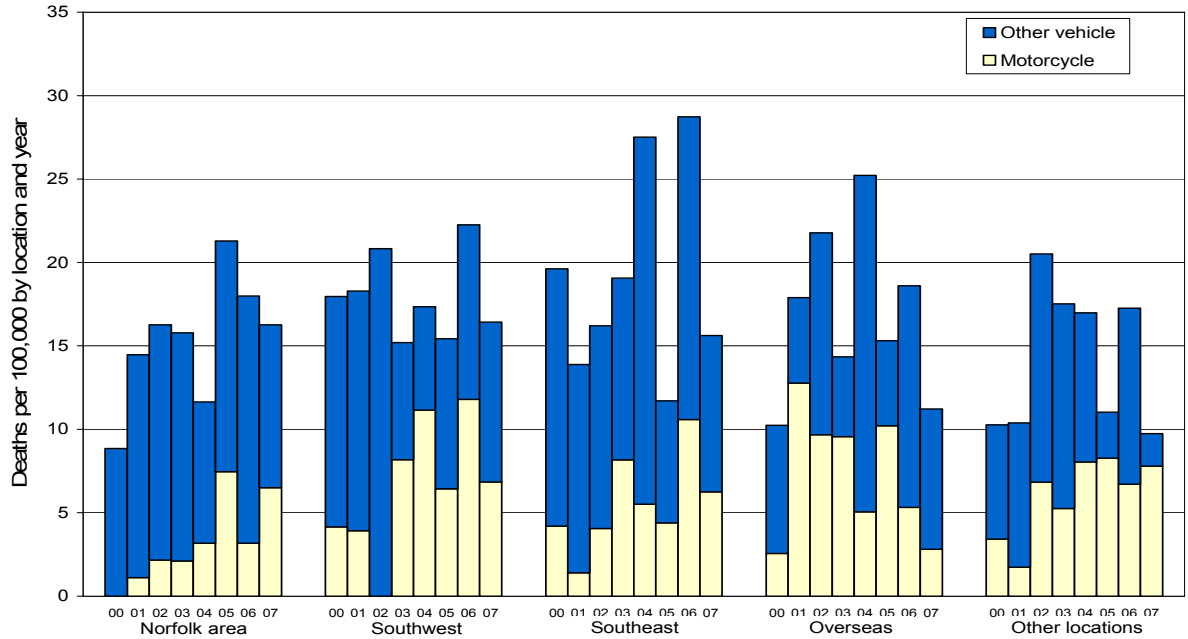


Motorcycle fatality rates are highest in the Southwest, Southeast, and overseas. Most overseas deaths have occurred in Italy and Japan, although these numbers seem to have declined in recent years. Automobile (other-vehicle) fatality rates have been highest in the Northeast and Northwest. Weather may explain some of the differences in fatality rates, with icy winters affecting automobile fatality rates in the Northeast and mild winters allowing for extended motorcycle usage in California and the Southeast.

**Trends in fatality rates by region**

In figure 10, we show the annual trends in vehicle fatality rates for the major regions. The four specifically identified regions together account for more than 70 percent of the Navy population.

Figure 10. Trends in vehicle fatality rates by region



The Norfolk area shows an increase in overall vehicle fatality rates, driven by an increase in motorcycle deaths. Motorcycle fatality rates for the Norfolk area in 2007 almost match levels that were typical for California. Overall vehicle fatality rates are essentially stable in the Southwest, with an increase in motorcycle death rates being offset by declining automobile rates. One of the good news stories is the downward trend in motorcycle fatality rates for the overseas locations. Overseas motorcycle fatality rates have come down fairly steadily from a FY 2001 peak. There were no overseas motorcycle deaths in FY 2008 (although those data were not yet available for our analysis).

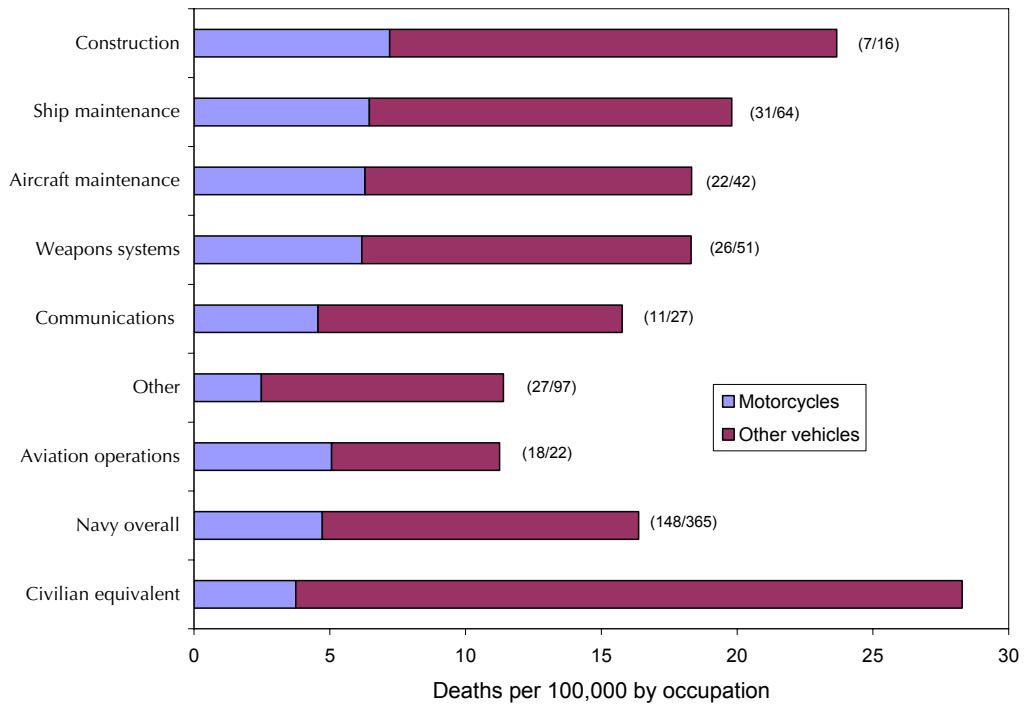
### Fatality rates by occupation

Figure 11 shows the vehicle fatality rates for selected occupational groups. Because there are so many enlisted occupational ratings, most with few fatalities, we grouped ratings into broad categories.<sup>5</sup>

5. Many individuals in the E1 to E3 paygrades do not fall within the rating structure. We assign those individuals to occupational groups based on their eventual ratings. Individuals who do not achieve a rating (including several deaths) are not included in the occupational groups or the figures.

The groupings are defined in appendix B. The numbers in parentheses in the figure indicate the total numbers of fatalities over the 8-year time period. The fatality rates are average annual rates over the time period, by occupational group.

Figure 11. Vehicle fatality rates by occupational category



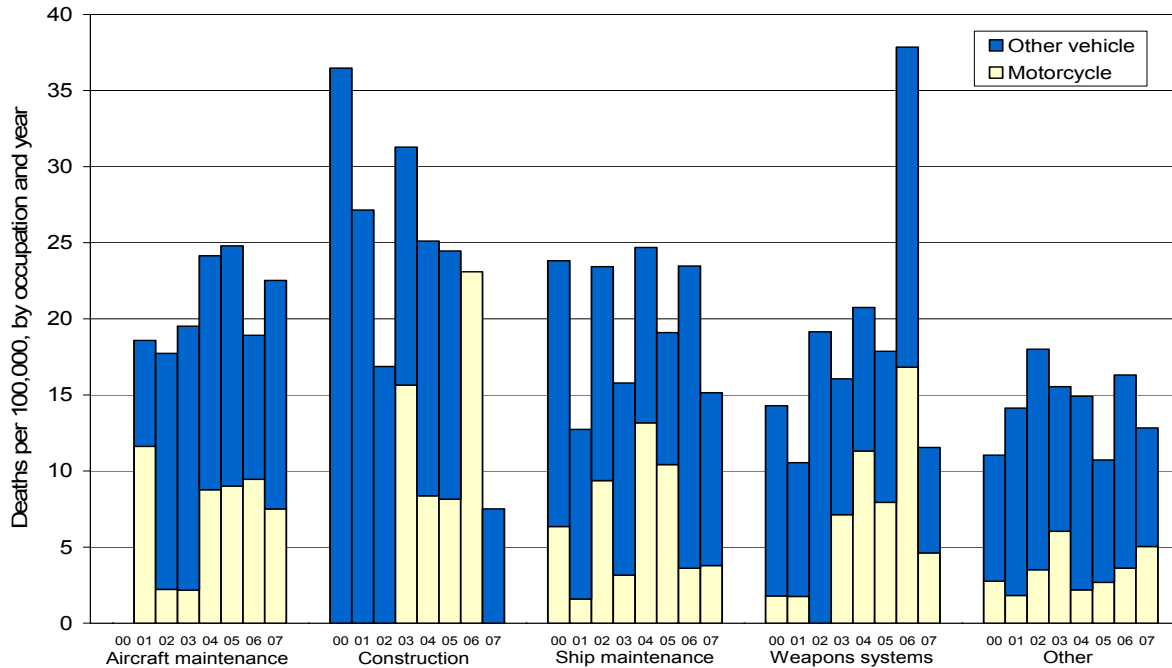
The highest vehicle fatality rates are for jobs related to construction,<sup>6</sup> ship maintenance, aircraft maintenance, and weapons systems. These groups are consistently high for both motorcycle and non-motorcycle fatalities. The aviation operations group stands out for having a high motorcycle fatality rate, despite a low automobile death rate. The group identified here as “other” includes administrative, communications, medical, security, ship operations, and supply ratings. This baseline group has low vehicle fatality rates for all vehicle types. Differences in death rates across occupations might indicate that some fields draw people who are more likely to take risks, or that certain jobs present the opportunity for greater risk (e.g., more free time).

<sup>6</sup> A recent CNA paper [4] looks at operational stress and post-deployment behavior among Seabees.

### Trends in fatality rates by occupation

Figure 12 looks at recent trends in fatality rates by occupation. The four groups identified (aircraft maintenance, construction, ship maintenance, and weapons systems) account for 50 percent of vehicle fatalities and 58 percent of motorcycle deaths.

Figure 12. Trends in vehicle fatality rates by occupational category



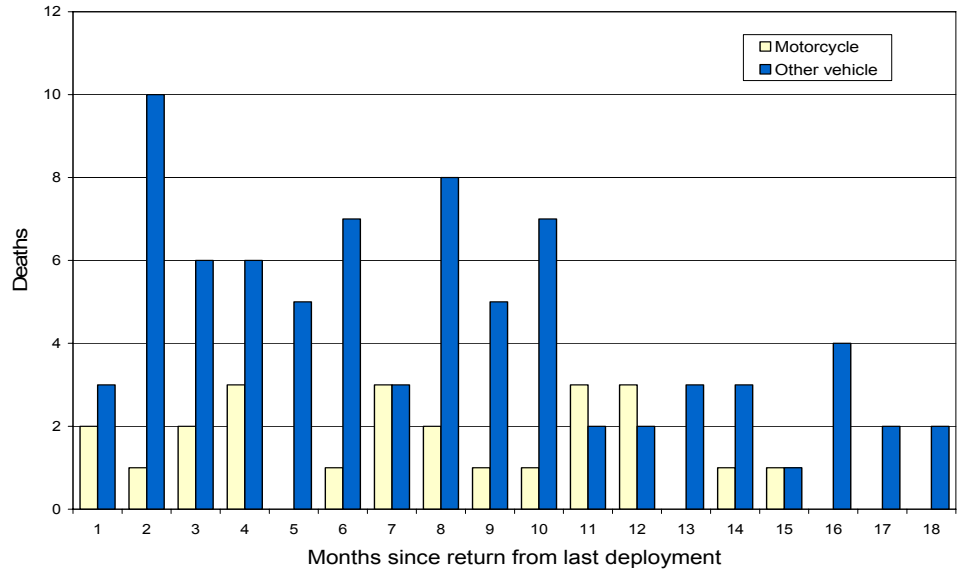
We see that fatality rates for the weapons systems group have been increasing, with motorcycle deaths contributing to that rise. The construction group has historically high vehicle fatality rates. Recent increases in the motorcycle fatalities for this group have largely offset an improvement in their automobile fatality rates.

### Fatalities following deployment

In figure 13, we show the frequency of vehicle-related death following deployment. The figure reflects vehicle deaths that occurred in the FY 2000 to FY 2008 time period. Overall, fatalities are relatively high over the 12 months following deployment. Of course, the subsequent decline in fatalities is not all that surprising since many individuals are, by then, on their next deployment. Still, the number of fatalities

does peak in the second month after deployment and again at 8 months. Motorcycle deaths don't appear to be as strongly related to deployment as automobile deaths.

Figure 13. Frequency of vehicle fatalities following deployment



Note that we do have some concern with the accuracy of our deployment data. We know when ships and squadrons are deployed and make the assumption that the individuals assigned to those platforms are also deployed. However, we have no data on individual augmentees who have been deployed.

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## Statistical modeling of vehicle deaths

The graphical presentation in the previous section provides a sense of the vehicle deaths in the Navy and it illustrates some trends and important comparisons. In and of themselves the graphs provide insight into what may be associated with accidents and some guidance for accident prevention programs. However, they do not allow us to completely unravel the many factors associated with fatal accidents. Consider the construction group which has a high fatality rate. Without further analysis, we are not sure whether this reflects specific characteristics of the occupation or if it might simply be due to a high concentration of young males within the group. To separate the effects of the various characteristics, we employ statistical analyses.

### The hazard rate model

We use a hazard rate model to conduct our analyses of factors associated with deaths. This method is commonly used in medical studies and it allows us to separate out the effects of a complex combination of risk factors that affect the probability of death over time.

The model asserts that the risk of a death depends on a set of personal characteristics. The purpose is to determine how those characteristics affect that risk. The output of the model is a set of hazard ratios. Hazard ratios compare the relative risk of death for two people who are the same except for a difference in one particular characteristic. These characteristics may be permanent (e.g., male) or transitory (e.g., deployed), so that the relative risks facing each individual can change over time.

A hazard ratio of 1 indicates that the risk is not appreciably different for sailors with that characteristic than for those without. A value of less than 1 indicates that those with the characteristic have lower risk. Similarly, values above 1 indicate a higher risk. Risks are multiplicative, so that the total risk facing an individual is the product of the hazard ratios for each of his or her characteristics.

For categorical variables, hazard ratios are defined only relative to a chosen baseline. For example, we might be interested in the effect of gender. We could choose to estimate the hazard ratio for the characteristic “male.” Suppose this hazard ratio for male is found to be 2. That means that the probability of death for males is twice that for female sailors. We could have equally chosen to consider the characteristic “female.” In that case, we would have found the hazard ratio for females to be 0.5, with their probability of death half that for males. The interpretation of hazard ratios always requires an understanding of the corresponding baseline characteristics. We list variables and their baselines in appendix C.

## **Advantages of the hazard rate model**

Hazard rate models are preferred to other standard regression techniques when working with data that deals with time to death. In particular:

- Hazard rate models explicitly account for the complex statistical process that underlies survival times.
- Hazard models specifically address data truncation. That is, they account for the fact that individuals are still at risk before and after the time covered by available data. By addressing this, the models avoid biased estimates.
- The approach easily deals with time-varying characteristics. In the model, characteristics are re-evaluated at each point in time. Designing a standard regression approach to explain survival time in this manner would present a challenge.

More generally, the method allows us to unravel the many factors and combinations of factors that might be associated with fatal accidents.

## **Variables of interest**

The variables we used in the final analysis were:

- Gender
- Geographic location



- Type of job
- Race/ethnicity
- Paygrade
- Age
- Time since joining the Navy (if paygrade is E1 to E3)
- Time since joining the current unit
- Time since return from an overseas command
- Time since promotion
- Time since demotion
- Marital status and dependents
- Deployment status
- Time since deployment
- Education
- Armed Forces Qualifying Test (AFQT) category
- Enlistment waivers<sup>7</sup>
- Quarter of the year
- Time trend

With the exception of the time trend, all of the variables that we look at with this model are categorical. For example, instead of using the AFQT numerical score as a variable, we assign everyone to one of three categories. We combine paygrade and age into sets of categorical variables (e.g., E4 to E6, age 21-24, E4 to E6, age 25-30).

## Estimated risks for vehicle-related deaths

This section describes the results of the hazard model estimation. We present three sets of results: one for all vehicles, one for motorcycles, and one for non-motorcycles. Following this, we consider whether

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7. Waiver categories are as defined in the Navy Recruiting Manual [5], except that we have grouped all traffic-related violations and offenses into a separate traffic category.

certain risks have changed over time. The results reflect the relative risk for enlisted personnel only.

## Results for all vehicle-related deaths

The first model we discuss evaluates the risk of overall vehicle-related deaths. The estimation results for the model of all vehicle-related deaths are listed in table 1. The first column of numbers gives the hazard ratio, which represents the relative risk associated with the variable, holding other variables constant. The second presents the p-values—a measure of statistical significance.

When interpreting results, it is important to consider statistical significance. The p-value indicates how sure we can be that the hazard rate differs from 1. Typically, researchers consider coefficients with p-values of less than 0.10 to indicate that the hazard associated with this variable does differ from the baseline level.

Table 1. Estimation results for the risk of all vehicle-related deaths

	Variable	Hazard ratio <sup>a</sup>	p-value <sup>b</sup>
<u>Demographic</u>	Male	2.74	0.00 ***
	Black	1.57	0.00 ***
	Hispanic	1.18	0.24
	Other race (non-white)	0.95	0.79
	Married or dependents	0.60	0.00 ***
<u>Region</u>	Norfolk area	1.02	0.89
	Southwest	1.22	0.26
	Northeast	1.46	0.12
	Northwest	1.23	0.34
	Southeast	1.43	0.05 **
	Overseas	1.11	0.63
<u>Job</u>	Aircraft maintenance	1.18	0.31
	Aviation operations	1.05	0.80
	Communications	1.21	0.34
	Construction	1.75	0.02 **
	Ship maintenance and engineering	1.33	0.06 *
	No rating / Gendets <sup>c</sup>	4.71	0.00 ***
	Weapons	1.16	0.35

Table 1. Estimation results for the risk of all vehicle-related deaths (cont'd)

	Variable	Hazard ratio <sup>a</sup>	p-value <sup>b</sup>
<u>Paygrade</u>	E1 to E3 first 90 days	0.00	0.00 ***
	E1 to E3 91 to 180 days	0.98	0.95
	E1 to E3 after first 180 days, age 17-20	2.45	0.00 ***
	E1 to E3 after first 180 days, age 21-24	1.98	0.01 **
	E1 to E3 after first 180 days, age 25 or older	2.25	0.02 **
	E4 to E6, age 17-20	2.46	0.01 **
	E4 to E6, age 21-24	3.61	0.00 ***
	E4 to E6, age 25-30	2.06	0.00 ***
	E4 to E6, age 31 or older	1.66	0.05 **
<u>Recent activity</u>	3 months or less since switching unit	0.86	0.32
	3 to 6 months since switching unit	1.09	0.52
	3 months or less since return from overseas	1.02	0.97
	Up to 3 months since promotion	1.01	0.94
	Demoted in last 3 months	1.34	0.48
	Demoted 3 to 6 months ago	0.77	0.72
	Currently deployed	0.00	0.00 ***
	Deployed within last 3 months	1.34	0.18
	Deployed between 3 and 6 months ago	1.37	0.17
<u>Education</u>	Deployed 6 to 9 months ago	1.53	0.06 *
	More than high school education	0.87	0.40
<u>AFQT</u>	Less than high school education	1.46	0.02 **
	AFQT score under 50	0.67	0.00 ***
<u>Enlistment waivers</u>	AFQT score 85 or higher	0.87	0.34
	Traffic waiver	2.01	0.13
	Serious misdemeanor or felony waiver	1.45	0.02 **
	Minor non-traffic waiver	0.93	0.90
<u>Time</u>	Drug or alcohol waiver	1.07	0.83
	Quarter 2 (Apr-Jun)	1.19	0.19
	Quarter 3 (Jul-Sep)	1.16	0.26
	Quarter 4 (Oct-Dec)	1.07	0.64
	Quarterly trend	1.01	0.29

a. For categorical variables, hazard ratios are interpreted relative to the categories not listed. For example, the black and Hispanic values are relative to whites and occupational values are relative to individuals in the groups not explicitly listed. See appendix C for details.

b. \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%.

c. The high hazard for the “No rating / Gendet” group comes about because this group includes many individuals who die in E1 to E3 paygrades. They will usually not have been assigned a rating.

Here we summarize the statistically significant results.

- Males face 2.7 times more risk than females. Black sailors face 1.5 times more risk than white sailors.
- The risk for those stationed in the Southeast is 1.4 times as high as in the baseline locations (Hawaii, Midwest, and Naval District Washington).
- People in construction fields have about 1.75 times the risk of people in the baseline groups (supply, administration, medical, and communications). Sailors in ship maintenance have about 1.3 times the risk of those in the baseline groups.
- Relative to the E7 to E9 baseline group, the other paygrades face significantly higher risk (except during the first 6 months of service).
- Risk generally declines with age, except for those few individuals who remain in the E1 to E3 paygrades past age 25.
- Individuals who are married or have dependents have only 0.6 times the risk of those who are single with no dependents.
- Individuals face a period of significant risk 6 to 9 months after deployment.
- People with less than a high school education (including those with a high school equivalency certificate) have about 1.5 times the risk of those with high school degrees.
- Individuals with enlistment waivers for serious non-traffic offenses have 1.5 times the risk of those who enter with no waiver.

## **Results for motorcycle fatalities**

Below we discuss the risk factors related to motorcycle deaths. Because there was only one enlisted female motorcycle fatality in the years 2000 to 2007, the analysis covers only enlisted males. The estimation results for motorcycle deaths are listed in table 2.

Table 2. Estimation results for the risk of all motorcycle deaths

	Variable	Hazard ratio	p-value <sup>a</sup>
<u>Demographic</u>	Black	1.68	0.02 **
	Hispanic	0.85	0.59
	Other race (non-white)	0.98	0.94
	Married or dependents	0.56	0.01 ***
<u>Region</u>	Norfolk area	0.68	0.27
	Southwest	1.50	0.19
	Northeast	0.96	0.94
	Northwest	0.48	0.16
	Southeast	1.21	0.56
	Overseas	1.76	0.10 *
	<u>Job</u>	Aircraft maintenance	2.21
Aviation operations		2.20	0.03 **
Communications		1.79	0.14
Construction		2.51	0.05 **
Ship maintenance and engineering		2.36	0.00 ***
No rating / Gendets		6.27	0.00 ***
Weapons		2.07	0.02 **
<u>Paygrade</u>	E1 to E3 first 90 days	0.00	0.00 ***
	E1 to E3 91 to 180 days	0.59	0.51
	E1 to E3 after first 180 days, age 17-20	0.74	0.56
	E1 to E3 after first 180 days, age 21-24	0.42	0.14
	E1 to E3 after first 180 days, age 25 or older	0.61	0.52
	E4 to E6, age 17-20	0.84	0.83
	E4 to E6, age 21-24	2.47	0.02 **
	E4 to E6, age 25-30	1.68	0.18
<u>Recent activity</u>	E4 to E6, age 31 or older	1.56	0.25
	3 months or less since switching unit	0.64	0.16
	3 to 6 months since switching unit	0.77	0.41
	3 months or less since return from overseas	1.04	0.97
	Up to 3 months since promotion	0.92	0.88
	Demoted in last 3 months	3.18	0.12
	Currently deployed	0.00	0.00 ***
	Deployed within last 3 months	1.07	0.88
Deployed between 3 and 6 months ago	0.92	0.88	
Deployed 6 to 9 months ago	1.53	0.31	

Table 2. Estimation results for the risk of all motorcycle deaths (cont'd)

	Variable	Hazard ratio	p-value <sup>a</sup>
<u>Education</u>	More than high school education	0.86	0.61
	Less than high school education	2.86	0.00 ***
<u>AFQT</u>	AFQT score under 50	0.90	0.64
	AFQT score 85 or higher	1.31	0.29
<u>Enlistment waivers</u>	Traffic waiver	1.50	0.69
	Serious misdemeanor or felony waiver	1.53	0.15
	Drug or alcohol waiver	2.45	0.03 **
<u>Time</u>	Quarter 2 (Apr-Jun)	2.25	0.01 ***
	Quarter 3 (Jul-Sep)	2.34	0.00 ***
	Quarter 4 (Oct-Dec)	2.13	0.01 ***
	Quarterly trend	1.03	0.00 ***

a. \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%.

Here we summarize some of statistically significant results for motorcycles:

- People stationed overseas have had almost twice the risk of a motorcycle fatality as those stationed in baseline locations. (We explore later whether this risk has declined in recent years.) The risk in the Southwest region is high, but not enough so as to be considered statistically significant.
- Those with jobs in construction, ship maintenance, aircraft maintenance, and aircraft operations have more than twice the risk of the baseline occupations.
- Paygrades E4 to E6 face a higher risk than those in other paygrades. This risk is significant for those aged 21 through 24.
- The risk is 3.2 times as high for those who were demoted in the past 90 days as it is for other individuals or times.
- Those with less than a high school diploma (including those with a high school equivalency) have almost three times the risk of high school graduates.
- Individuals with drug or alcohol waivers have 2.5 times higher risk than those with no enlistment waivers.

- Return from deployment has no significant effect on motorcycle fatality rates.
- Seasonal swings in motorcycle fatalities are more pronounced than for other vehicle deaths. The risk of fatality is more than twice as high in the spring, summer and fall as in the baseline winter quarter.

## Results for non-motorcycle fatalities

Lastly, we present the results on key risk factors for non-motorcycle fatalities (primarily automobile deaths). These results help explain some of the differences between the all-vehicle and motorcycle results. Table 3 shows the results from the model run for non-motorcycles.

Table 3. Estimation results for the risk of non-motorcycle deaths

	Variable	Hazard ratio	p-value <sup>a</sup>
<u>Demographic</u>	Male	2.28	0.00 ***
	Black	1.54	0.00 ***
	Hispanic	1.15	0.41
	Other race (non-white)	0.93	0.75
	Married or dependents	0.63	0.00 ***
	<u>Region</u>	Norfolk area	1.18
	Southwest	1.09	0.70
	Northeast	1.89	0.02 **
	Northwest	1.66	0.05 **
	Southeast	1.60	0.03 **
	Overseas	0.93	0.78
<u>Job</u>	Aircraft Maintenance	1.08	0.71
	Aviation Operations	0.87	0.58
	Communications	1.32	0.25
	Construction	1.79	0.04 **
	Ship maintenance and engineering	1.25	0.23
	No rating / Gendets	4.66	0.00 ***
	Weapons	1.07	0.71

Table 3. Estimation results for the risk of non-motorcycle deaths (cont'd)

	Variable	Hazard ratio	p-value <sup>a</sup>
<u>Paygrade</u>	E1 to E3 first 90 days	0.00	0.00 ***
	E1 to E3 91 to 180 days	1.40	0.51
	E1 to E3 after first 180 days, age 17-20	3.85	0.00 ***
	E1 to E3 after first 180 days, age 21-24	3.30	0.00 ***
	E1 to E3 after first 180 days, age 25 or older	3.73	0.00 ***
	E4 to E6, age 17-20	4.11	0.00 ***
	E4 to E6, age 21-24	4.62	0.00 ***
	E4 to E6, age 25-30	2.19	0.03 **
	E4 to E6, age 31 or older	1.76	0.11
<u>Recent activity</u>	3 months or less since switching unit	1.00	0.98
	3 to 6 months since switching unit	1.27	0.13
	3 months or less since return from overseas	1.11	0.86
	Up to 3 months since promotion	0.99	0.96
	Demoted in last 3 months	1.13	0.81
	Demoted 3 to 6 months ago	1.00	0.98
	Currently deployed	0.00	0.00 ***
	Deployed within last 3 months	1.59	0.06 *
	Deployed between 3 and 6 months ago	1.62	0.07 *
<u>Education</u>	Deployed 6 to 9 months ago	1.72	0.04 **
	More than high school education	0.85	0.43
<u>AFQT</u>	Less than high school education	1.00	1.00
	AFQT score under 50	0.63	0.01 **
<u>Enlistment waivers</u>	AFQT score 85 or higher	0.72	0.10 *
	Traffic waiver	2.32	0.10 *
	Serious misdemeanor or felony waiver	1.53	0.03 **
	Minor non-traffic waiver	1.46	0.52
<u>Time</u>	Drug or alcohol waiver	0.52	0.20
	Quarter 2	0.95	0.76
	Quarter 3	0.97	0.82
	Quarter 4	0.86	0.35
	Quarterly trend	1.00	0.68

a. \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%.



Among the statistically significant results for automobile deaths are the following:

- The risk of automobile death is very high in the Northeast, Northwest, and Southeast. In each region, the risks are more than 1.5 times as high as for the baseline locations.
- Individuals in construction have a significantly higher risk for automobile related deaths than those in baseline occupations.
- Those in paygrades E1 to E6 may face more than three times the risk of those in the baseline E7 to E9 paygrades. For the E4 to E6 paygrades, risk declines with age. However, for the E1 to E3 paygrades, risks remain high even for individuals over the age of 25.
- After returning from deployment, the risk is about 1.6 times higher than at other times. The risk is highest in the interval 6 to 9 months after deployment.
- Individuals who enter with traffic waivers have a risk 2.3 times higher than those who enlist with no waivers. Those with waivers for serious non-traffic offenses have a risk 1.5 times higher.
- Males face a much higher risk of an automobile fatality than do females.
- Individuals with low and high AFQT scores have much less risk of an automobile fatality than do those with average scores.

## Changes in risk over time

In this final section, we explore whether relative risks have been changing over time. In the graphical analysis, we saw a troubling increase in motorcycle fatality rates among mid-level enlisted ranks. Other trends of concern were the increasing motorcycle fatality rates for the construction and weapons systems groups. We also noted that motorcycle deaths have increased in several Navy regions.

However, despite these concerns, there were also some positive trends—declining automobile deaths rates at some locations and a de-

cline in motorcycle deaths overseas. These improvements may point to lessons that can be applied elsewhere.

Here we investigate those trends to determine whether the hazards have in fact changed significantly over time. We explore the hazard rate changes for the four regions with the highest numbers of motorcycle fatalities (Southwest, Southeast, the Norfolk area, and overseas). We also look at the changes in risk for the E4 to E6 paygrades (focusing specifically on the 21 to 25 year olds who are at most risk). Finally, we look at the construction and weapons systems ratings group.

Whereas our earlier analyses gave us average hazard rates for the entire time period, we now estimate separate hazard rates for two intervals. We compare hazard rates in later years (FY 2004–FY 2007) to those in the earlier years (FY 2000–FY 2003). The overall models are unchanged, except for the addition of variables to identify changes in hazard rates over time. These variables allow us to test whether hazard rates have changed significantly between those two time periods. The results are presented in table 4.

Table 4. Estimation results for the change in hazard rates over time

<u>Motorcycles</u>		Hazard rate <sup>a</sup> (FY00–FY03)	Hazard rate (FY04–FY07)	Significant difference
	Norfolk area	0.38 *	0.92	◦
	Southwest	1.15	1.79 *	
	Southeast	1.03	1.36	
	Overseas	2.56 **	1.21	◦
	Weapons	1.06	2.89	**
	Construction	1.78	2.99 **	
	E4 to E6, 21 to 25 years old	1.83	2.91	
<u>Automobiles</u>		Hazard rate (FY00–FY03)	Hazard rate (FY04–FY07)	Significant difference
	Norfolk area	1.18	1.17	
	Southwest	1.27	0.87	◦
	Southeast	1.41	1.83 **	
	Overseas	0.75	1.03	
	Weapons	1.14	1.01	
	Construction	2.33 **	1.20	
	E4 to E6, 21 to 25 years old	5.16	4.08	

a. \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%, ◦ significant at 20%. The final column indicates whether the change in hazard rates is statistically significant.

### **Changes in risk by region**

There has been an increase in the likelihood of motorcycle death for both the Norfolk area and the Southwest region. Despite large numerical changes in the estimated hazard ratios, only the increased hazard in the Norfolk area can be considered close to statistically significant. There has been a substantial decline in risk of motorcycle fatalities at overseas locations. This change is on the borderline of being statistically significant. However, more recently available data, which continues to show very low number of fatalities overseas, does suggest something has changed.

There has been a decrease in the risk of automobile death for the Southwest region. In the Southeast, there has been an increase in automobile risk, although the change is not statistically significant.

### **Changes in risk by occupation**

The two occupational groups that seem to have the biggest increase in risk are weapons systems and construction. For the weapons group, there has been large and significant increase in the risk of motorcycle death. For the construction group, although the estimated risk has increased substantially, this change is not yet statistically significant. The small size of this group is the reason this change is not significant.

### **Changes in risk by paygrade**

Surprisingly, there is no statistically significant change in risk for the E4 to E6 group. Although the risk for motorcycle death is higher in the later years, the change itself is not significant. Overall, a decrease in automobile risk for this group offsets their increased motorcycle risk.

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## Appendix A: Definitions of regions

These are the regions used in the analysis:

- *Norfolk area:*  
North Carolina and Virginia (except areas within Naval District Washington)
- *Northeast:*  
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
- *Northwest:*  
Oregon, Washington, Alaska, Idaho, Montana, and Wyoming
- *Overseas:*  
All locations outside the Continental United States, except Hawaii and Alaska
- *Southeast:*  
Alabama, Florida, Georgia, Louisiana, Mississippi, Texas, and South Carolina
- *Southwest:*  
Arizona, California, Nevada, and Utah
- *Other:*  
Locations not listed above, including Hawaii, Navy Region Midwest, and Naval District Washington

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## Appendix B: List of ratings in job categories

Ratings are grouped into these categories for the analysis

- *Administrative:*  
AZ, DK, DM, DP, PN, YN
- *Aircraft maintenance:*  
AD, AE, AM, AME, AMH, AMS, AS, AT, AV
- *Aviation operations:*  
AB, ABE, ABF, ABH, AC, AF, AG, AO, AW, PR
- *Communications:*  
CTA, CTI, CTM, CTN, CTO, CTR, CTT, DS, EW, IS, IT, SM
- *Construction:*  
BU, CE, CM, CU, EA, EO, ML, SW, UC, UT
- *No rating / Gendets:*  
Individuals who did not achieve an occupational rating within the time period covered by our data
- *Medical:*  
DT, HM, and OM
- *Security:*  
MA
- *Ship maintenance and engineering:*  
DC, EN, GS, GSE, GSM, HT, IC, MM, MN, MR, ND, PM
- *Ship operations:*  
BM, IM, SBSO, and QM
- *Supply:*  
AK, EQ, PC, SH, and SK
- *Weapons systems:*  
ET, FC, FT, GM, MN, MT, OS, STG, STS, TM, WT

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## Appendix C: List of categorical variables and their baselines

Table 5. List of categorical variables and their baselines

Variables	Baseline
<u>Location</u>	
Overseas	All other US locations: e.g., Hawaii, Navy Region Midwest, and Naval District Washington
Norfolk area	
Northeast	
Northwest	
Southeast	
Southwest	
<u>Occupational field</u>	
Aircraft maintenance	All other occupational fields, including supply, administrative, communications, ship operations, security, and medical
Aviation operations	
Communications	
Construction	
No rating / Gendets	
Ship maintenance and engineering	
Weapons systems	
<u>Race/ethnicity</u>	
Hispanic; black; other non-white race	White
<u>Paygrade / time in service / age</u>	
E1 to E3 (first 3 months after joining)	E7 to E9
E1 to E3 (3 to 6 months since joining)	
E1 to E3 (6 months or more since joining, age 17-20)	
E1 to E3 (6 months or more since joining, age 21-24)	
E1 to E3 (6 months or more, age 25 or older)	
E4 to E6 (age 17-20)	
E4 to E6 (age 21-24)	
E4 to E6 (age 25-30)	
E4 to E6 (age 31 or older)	
<u>Career events—new command</u>	
3 months or less since reporting to command	Other months
3 to 6 months since reporting to command	
<u>Career events—return from overseas</u>	
3 months or less since return from overseas command	Other months

Table 5. List of categorical variables and the baselines (cont'd)

Variables	Baseline
<u>Career events—demotion/promotion</u>	
Promoted within last 3 months	Other months
Demoted within last 3 months	
Demoted 3 to 6 months ago	
<u>Career events—months since deployment</u>	
0 to 3 months since deployment	Other months, when not deployed
3 to 6 months since deployment	
6 to 9 months since deployment	
<u>Career events—deployment</u>	
Deployed	Not deployed
<u>Education and test scores</u>	
More than high school; less than high school (including high school equivalency)	High school degree
AFQT score 1 to 50; AFQT score 85 or higher	AFQT score 50 to 84 or missing
<u>Miscellaneous demographics</u>	
Male	Female
Single with no dependents	Married, or with dependents
<u>Enlistment waivers</u>	
Traffic waivers; serious non-traffic waivers (including felony); minor non-traffic waivers; drug or alcohol waivers	No enlistment waivers
<u>Time of year</u>	
Apr–Jun quarter; Jul–Sep quarter; Oct–Dec quarter	Jan–Mar quarter

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