April 2016

White paper

somewhat different

In general, major violations are associated with increased mortality

All-cause mortality by type of motor vehicle violation

Introduction

This paper analyzes all-cause mortality associated with different types of driving violations using data provided by LexisNexis®. Some interesting observations emerged during the analysis. There are two forms of mortality surcharge employed by life insurance underwriters when assessing risk. These techniques are referred to as table ratings and flat extras. From the analysis, table ratings appear to be a more accurate measurement of surcharge.

The degree of risk varies according to the violations studied. This paper will explore types of violations, as well as the inherent extra mortality encountered. With respect to the violations studied, the strongest correlation with extra mortality is associated with driving while impaired. The next-strongest correlation is with suspensions/revocations, followed closely by reckless/negligent driving. Speeding mortality is associated with the degree of speeding in miles per hour (MPH) over the speed limit, in addition to the number of speeding events. Accidents are associated with extra mortality, but accident violations did not produce findings as adverse as other violations reported here. In general, major violations are associated with increased mortality throughout the study observation period.

hannover re®

There are limitations associated with this analysis. The study was conducted on a general population rather than an underwritten insured population. Results from an insured population may vary from results presented here.

Construction of the Study

Thanks to the tremendous support of LexisNexis®, Hannover Re was provided a de-identified database of over 8.5 million motor vehicle records (MVRs) where permitted for research purposes. The earliest recorded results date back to January 2006. Additional entries occurred through year-end 2010 and all were followed through February 2014. Due to the extended follow-up period, mortality by violation can be traced over a considerable period of time. This allows for analysis of trends in extra mortality by duration subsequent to violation event.

Deaths were identified by LexisNexis®, using the Social Security Death Master File, along with other matching techniques. These additional matching techniques can identify an estimated 40% more deaths than those found using the Social Security register alone. LexisNexis® is in the business of data aggregation, data validation and scrubbing. As such, it was capable of producing results which allowed this study to occur. In total, over 200,000 deaths were observed during the study period.

The data was cleaned by eliminating records with missing variables or unrealistic findings. The remaining 8.3 million records were appended with an expected mortality assumption based on the 2009 United States Population Life Tables[1] applying customary actuarial techniques. These tables are age and gender distinct, which means results have been adjusted for the confounding influence of these factors. The observed deaths were divided by the expected deaths according to the 2009 U.S. Population Tables in the column titled Obs/US Pop. Results were standardized by comparing the mortality rate for the observed population to the mortality rate for the population with no violations in the SMR (Standardized Mortality Ratio) column, unless otherwise noted. The population studied was a random sample of the United States population comprised primarily of individuals applying for automobile insurance.

The MVR data includes date of MVR acquisition, along with up to 10 violation codes, and their related violation dates. This allowed for expression of violation results relative to the date of MVR collection. In this manner, results can be analyzed by duration since violation. These violation codes were standardized by LexisNexis®. Standardized Violation Codes (SVC) allow for consistent treatment of like violations when jurisdictions use slightly different verbiage or coding to describe the same type of violation.

SVC codes are detailed views of a specific violation and lend themselves to combination when considering similar violations. For example, speeding violations may fall under 1-5 MPH over the limit for one code, or 6-14 MPH over the limit for a different code. Both can be placed into a broader category of speeding that is within a range of 1-15 MPH over the limit.

Table Ratings versus Flat Extras

There are primarily two forms of mortality surcharge employed by life insurance underwriters when assessing risk. These techniques are referred to as table ratings and flat extras. Underwriters will employ one or both of these methods to reflect the extra risk present. Applicants who do not exhibit extra risk are referred to as standard risks. This comprises a vast majority of the population that applies for life insurance.

Underwriters use debits when the mortality risk is proportionately increased relative to a non-impaired, standard risk class baseline. A common practice in the individual life insurance industry is to consider one debit equal to a 1% increase in mortality and one credit equal to a 1% reduction in mortality relative to the standard baseline. As such, risk is proportional to the baseline when using this form of surcharge. As age increases, so does mortality. When risk proportionally increases over a constantly changing age-dependent baseline, debits are used. In that manner, risk is relative to the baseline mortality rate. It is a common practice to group ranges of debits into risk classes or tables. Often, 25 debits are used per risk class or table. For example, a Table 2 rating suggests a 50 debit assessment or a 50% increase in mortality.

On the other hand, flat extra surcharges are not proportional to a baseline age-dependent mortality rate. Flat extra surcharges are employed when risk is age independent. Dangerous occupations or private pilots are possible examples of when a flat extra surcharge might be applied. In these instances, the risk does not depend on the person's age; rather the risk depends on the characteristics of the risk performed. The death rates observed are measured in deaths per thousand persons exposed to the risk on an annual basis.

To further clarify this concept, here's an example. If a non-impaired population of 40-year-olds exhibits one death per thousand persons per year, and 50-year-olds exhibit two deaths per thousand per year, mortality can be expressed relative to these baselines. For the moment, assume mortality for a certain type of driving violation is constant at two times, or 200%, of these age baselines. Because one debit equals a 1% increase in mortality, then mortality that is twice the baseline means a 100% increase in mortality, which equals 100 debits. Two hundred percent (200%) of the baseline 40-year-old mortality rate is two deaths per thousand (200% x 1 = 2). The extra number of deaths per thousand is one death. The excess death rate can be expressed as a table rating associated with 100 debits or as a flat extra of one extra death per thousand for 40-year-olds. For the 50-year-olds, 200% of two equals four deaths (200% x 2 = 4). The excess death rate per thousand for the 50-year-olds is two extra deaths per thousand. Even though the table rating associated with 100 debits remained constant for the 40- and 50-year-olds, the number of extra deaths per thousand increased.

On the other hand, assume the extra number of deaths observed were constant. Then it is the debits that would change. For the moment, now assume a driving violation produced one extra death per thousand people, independent of age. For the 40-year-olds, the death rate is added to the baseline, and again produces two deaths per thousand, which equals a 200% mortality rate. This is twice the baseline mortality rate – and again, equal to 100 debits. For 50-year-olds, adding only one extra death per thousand to a baseline expected of two deaths per thousand produces three deaths per thousand. Relative to a baseline of two deaths per thousand means the mortality is 150% of expected deaths (2 + 1 = 3 and 3/2=1.50 or 150%). This 150% of expected mortality, which is a 50% increase over expected mortality, translates to 50 debits. In this second example, the one extra death per thousand remains constant, while the mortality ratio changes with age.

In brief, extra mortality can be expressed as either a table rating or a flat extra. Additionally, it can be seen that one surcharge approach may be more appropriate when expressing the extra risk. Thus by analyzing results in terms of both excess death rates per thousand and as mortality risk relative to an age-dependent baseline, one method will stand out as superior.

Research Results

Driving Under the Influence (DUI)

DUI includes violations for excess blood alcohol levels as well as violations for driving under the influence of drugs. Results are stratified by age group and time since violation occurred. Age is established at time of MVR query. The age groups include 17- to 39-year-olds, 40- to 59-year-olds, and ages 60 and up. Duration since the violation occurred is calculated using the date the MVR was obtained and the date the violation occurred. In the following table, results are expressed as 0 to 2 years (DUI 0-2 YRS), > 2 to 5 years (DUI 3-5 YRS), and > 5 years (DUI 6+ YRS) prior to the date of MVR acquisition. Exposure-years reflect the sum of all the person-years the population contributes to the study and is measured consistent with actuarial principles.

The expected population mortality rate is derived by appending the expected mortality to each of the individuals in the study, based on the 2009 U.S. Population mortality tables. In this manner, the expected mortality is adjusted for age and gender. Observed deaths, relative to the U.S. population's expected deaths, are listed in the Obs/US Pop column of the following tables. The NO VIO group is comprised of individuals who had clean MVRs with no violations of any kind. The mortality rate for this group, relative to the U.S. Population table, represents the expected mortality rate that the other cohorts are compared to. In this manner, the results are standardized and mortality ratios are referred to as Standardized Mortality Ratios (SMR).

The letter q in the heading of the following tables refers to the mortality rate (total deaths divided by total exposure-years) for the observed population and q' represents the standardized expected mortality rate for the population. Mortality is expressed relative to 1,000 person-years of exposure. The difference in observed and expected mortality, (q-q'), is multiplied by 1,000 to produce a death rate per 1,000 person-years. This is displayed in the tables that follow as (q-q')1000. These findings may also be referred to as flat extras (FE) seen elsewhere in this paper.

The results are consistent with methods traditionally applied to life insurance analysis, whereby excess mortality is described as both a mortality ratio and a flat extra[2]. This serves to highlight the appropriate surcharge approach, either table rating or flat extra, for reflecting a more accurate risk.

If mortality was age independent, then the extra deaths per thousand (q-q')1000 would be constant across all three age bands and the standardized mortality ratios would vary. However, if mortality was age dependent, then mortality ratios would be constant and the extra deaths per thousand would vary by age. Standardized mortality ratios for 17- to 39-year-olds as well as 40- to 59-year-olds are strikingly similar. DUI violations that were within two years of MVR produce standardized mortality ratios of 261% and 262% for 17- to 39-year-olds and 40- to 59-year-olds, respectively. DUI violations that were three to five years ago produce standardized mortality ratios of 230% and 232%, respectively. Finally, for DUI violations occurring six or more years ago, mortality ratios are 216% and 209%, respectively.

The flat extras (extra deaths per thousand) for these two age groups are quite different. For example, DUI violations occurring within two years of MVR produce 1.29 extra deaths per thousand and 5.75 extra deaths per thousand, respectively. For the other two violation categories (3-5 YRS and 6+ YRS), the flat extras are 1.08 versus 4.71 and 1.09 versus 3.97 extra deaths per thousand (see Table 1).

For ages 60 and older, the mortality ratios decrease, while the flat extras continue to increase. This is due to the larger standardized baseline expected mortality rate associated with older individuals. The flat extras are not constant across all ages and are therefore not age independent. Mortality ratios provide more homogeneous results especially for ages 17-39 and 40-59.

Results are stratified into decennial ages. The goal is to observe the mortality ratios and flat extras across decennial age bands to see if similar patterns are retained at this more granular level. According to the results in Table 2, there is less variation in mortality ratios (SMRs) than flat extras (FEs).

Mortality is also analyzed by duration. This explores how long the extra mortality persists. The DUI events are again split into the same 3 subpopulations, where the DUI occurs either within two years of MVR (DUI within 2 years), or > 2-5 years ago (DUI within 3-5 years), and finally DUI violations occurring > 5 years ago (DUI 6 years or greater). All ages are combined to track a larger population across time. Each duration spans one year of follow-up.

Based on the date of DUI violation relative to MVR query, Table 3 traces mortality through eight years of follow-up.

In graphing these findings, Figure 1 shows that even out to eight years from the date of the MVR query, mortality remains higher for all three groups than the mortality exhibited by individuals with no violations. Mortality ratios are just under 200% for all three cohorts at eight years. Mortality has graded downward for all groups, but still remains higher than the baseline referent.


Law enforcement administering a field sobriety test

Table 1 – Mortality by Age Group and Years since DUI Violation

Age Group	DUI Group	Exposure-yrs	Deaths	Obs/US Pop	SMR	(q-q')1000
17-39	NO VIO	12,489,041	9,008	61%	100%	0.00
	DUI 0-2 YRS	334,624	697	160%	261%	1.29
	DUI 3-5 YRS	265,922	510	141%	230%	1.08
	DUI 6+ YRS	128,405	261	132%	216%	1.09
40-59	NO VIO	11,097,657	39,554	67%	100%	0.00
	DUI 0-2 YRS	138,281	1,286	177%	262%	5.75
	DUI 3-5 YRS	124,842	1,033	157%	232%	4.71
	DUI 6+ YRS	117,648	896	141%	209%	3.97
60+	NO VIO	4,338,772	90,996	77%	100%	0.00
	DUI 0-2 YRS	15,309	442	134%	173%	12.21
	DUI 3-5 YRS	13,989	430	140%	181%	13.78
	DUI 6+ YRS	14,201	428	131%	170%	12.37

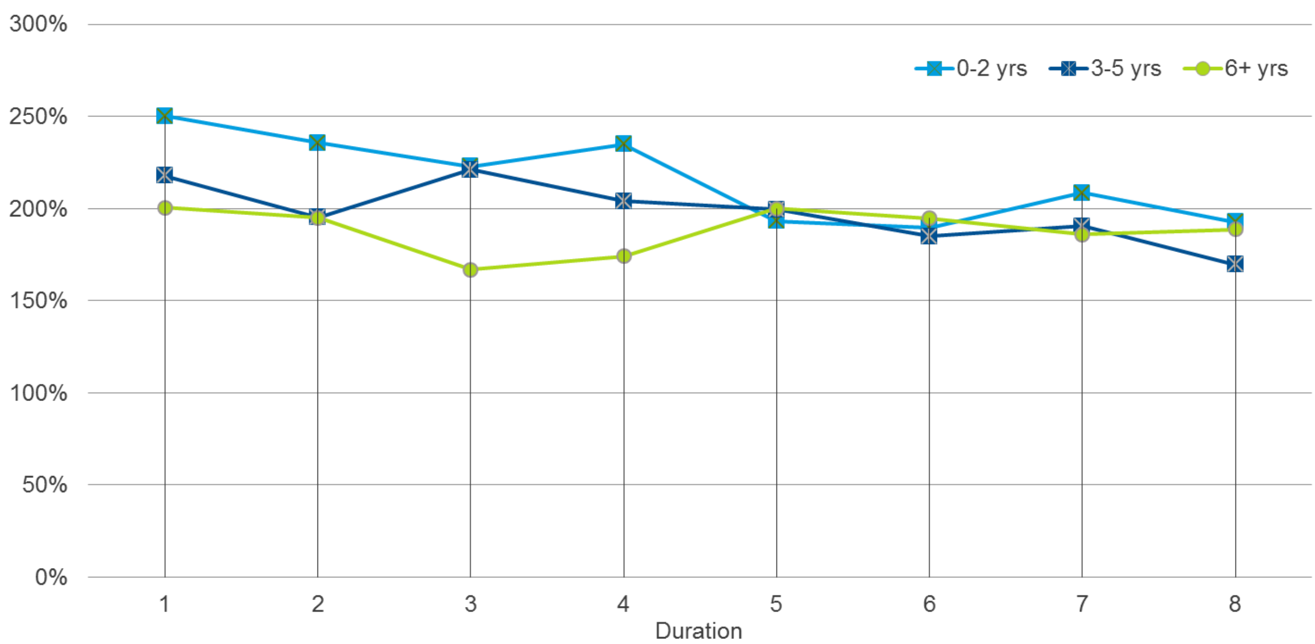
Table 2 – Mortality by Decennial Age Groups and Years since DUI Violation

Age Group	DUI 0-2 YRS		DUI 3-5 YRS		DUI 6+ YRS	
	SMR	FE	SMR	FE	SMR	FE
20-29	255%	1.05	231%	0.90	276%	1.25
30-39	276%	1.79	239%	1.43	195%	1.01
40-49	269%	4.05	243%	3.44	204%	2.55
50-59	262%	9.15	228%	7.31	218%	6.72
60-69	196%	12.49	198%	12.67	194%	12.39
70-79	149%	14.98	165%	19.91	145%	13.96

Table 3 – Mortality for DUI within 2, 3-5 and 6 Years or Greater from MVR

Duration	DUI within 2 Years from MVR			DUI within 3-5 Years from MVR			DUI 6 Years or Greater from MVR		
	Exposure-yrs	Deaths	SMR	Exposure-yrs	Deaths	SMR	Exposure-yrs	Deaths	SMR
1	87,915	416	250%	72,293	318	218%	47,723	258	201%
2	87,499	443	236%	71,975	322	195%	47,465	285	195%
3	87,056	436	223%	71,653	379	221%	47,180	255	167%
4	80,871	439	235%	66,638	335	204%	43,516	255	174%
5	63,140	295	193%	52,313	272	200%	33,225	237	200%
6	44,349	204	190%	37,395	182	185%	22,583	161	195%
7	26,731	139	208%	22,964	119	191%	13,136	94	186%
8	10,485	52	193%	9,366	44	170%	5,338	40	189%

Figure 1 – DUI Mortality Rate by Duration (in years)



Suspensions/Revocations

License suspensions and revocations produce results that mirror DUIs, except the mortality rates are slightly lower. As with DUIs, the results reflect higher mortality by violation, even when the event occurs over 6 years prior (Tables 4a and 4b). After aggregating all ages together, violations within 2 years, 3 to 5 years, and 6+ years ago, produce standardized mortality rates of 199%, 189%, and

165%, relative to individuals with no violations, respectively (Table 4a).

Table 4b shows results by age band with age and duration groupings that mirror DUI Table 1, indicating the standardized mortality ratios are slightly lower than those for DUI violations. Additionally, the flat extra death rates per thousand vary by age band, whereas the standardized mortality ratios are again more homogenous, especially when comparing ages 17-39 and 40-59.

Figure 2 graphs the suspension-revocation grade-off for all ages combined over eight durations by violation group. Relative to those with no violations and viewed by duration, results mirror DUIs, in general, slightly lower than DUI mortality, but still increased at eight years out.

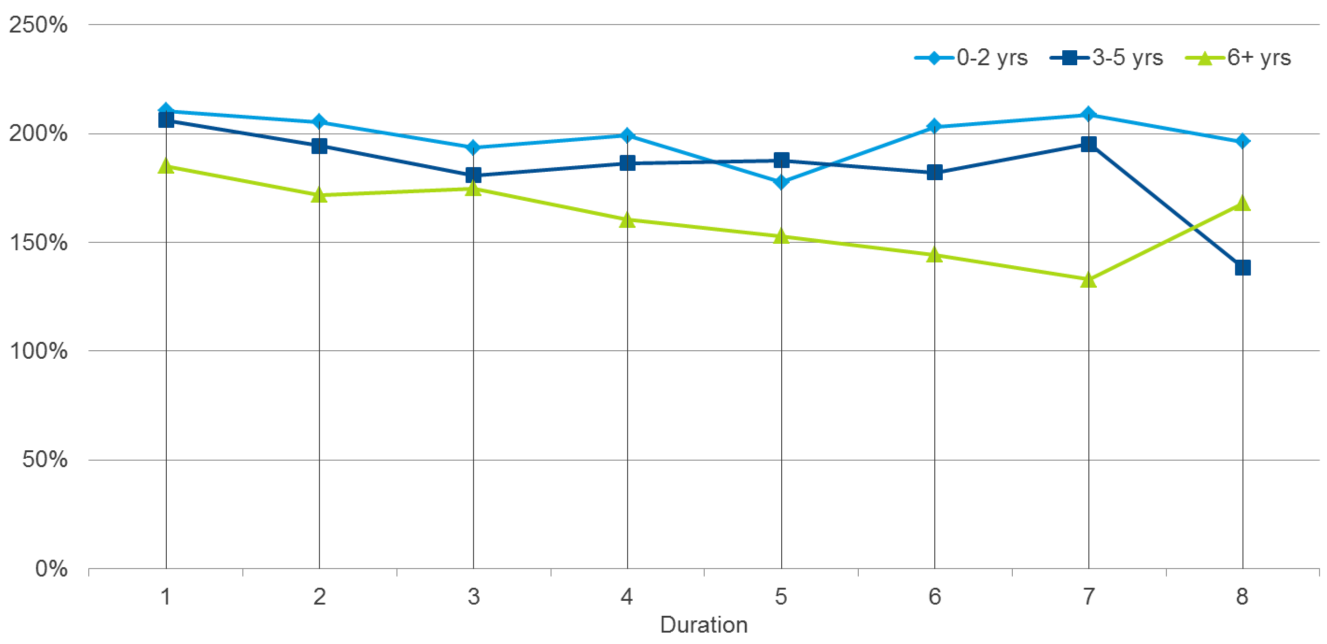
Table 4a – Overall Suspension Revocation Results

Category	Exposure-yrs	Deaths	Obs/US Pop	SMR
NO VIO	27,925,470	139,558	73%	100%
SUS REV 0-2 YRS	973,614	3,947	145%	199%
SUS REV 3-5 YRS	502,115	1,986	138%	189%
SUS REV 6+ YRS	197,643	1,017	120%	165%

Table 4b – Suspension Revocation Results by Age Group and Years since Violation

Age Group	Sus Rev Group	Exposure-yrs	Deaths	Obs/US Pop	SMR	(q-q')1000
17-39	NO VIO	12,489,041	9,008	61%	100%	0.00
	SUS REV 0-2 YRS	713,098	1,285	143%	235%	1.03
	SUS REV 3-5 YRS	356,845	606	129%	211%	0.89
	SUS REV 6+ YRS	106,972	157	100%	164%	0.57
40-59	NO VIO	11,097,657	39,554	67%	100%	0.00
	SUS REV 0-2 YRS	234,322	1,769	153%	227%	4.22
	SUS REV 3-5 YRS	132,154	1,005	152%	225%	4.23
	SUS REV 6+ YRS	79,954	544	128%	189%	3.21
60+	NO VIO	4,338,772	90,996	77%	100%	0.00
	SUS REV 0-2 YRS	26,195	893	135%	175%	14.63
	SUS REV 3-5 YRS	13,116	375	122%	158%	10.46
	SUS REV 6+ YRS	10,717	316	121%	157%	10.65

Figure 2 – Suspension Revocation Mortality Rate by Duration



Reckless Negligent Driving

Reckless and negligent driving violations also produce higher mortality that is lower than DUI mortality and close to that of individuals who had their license suspended or revoked (Table 5).

Consistent with the previous violation categories, if the violation occurred six or more years prior to MVR acquisition, the mortality remains increased, producing a mortality rate that is 176% of those with no violations.

Table 5 – Overall Reckless Negligent Results

Category	Exposure years	Deaths	Obs/ US Pop	SMR
No Vio	27,925,470	139,558	73%	100%
Rec Neg 0-2 yrs	110,770	448	143%	196%
Rec Neg 3-5 yrs	73,709	263	121%	165%
Rec Neg 6+ yrs	20,749	100	128%	176%

Speeding

Speeding violations are split into three categories based on degree of speeding over the speed limit. The speeding categories are 1-15 MPH, 16-30 MPH, and 31-UP MPH. In addition to MPH, the number of speeding events was a contributing factor to mortality. The referent population is comprised of anyone with no violations. Mortality rates are displayed relative to that group. Due to the small numbers associated with some of these findings, confidence intervals are placed after the SMRs to describe the 95% confidence interval associated with these results, employing Byar's approximation to the Poisson[3] (LL is lower limit and UL, upper limit). Some findings lack statistical credibility, but are included since their mortality patterns are interesting. Choosing a confidence interval other than 95% would also change the upper (UL) and lower limits (LL) of credibility.

When the violation speed is 1-15 MPH, there is a negligible mortality impact associated with these infractions until they become frequent. Table 6 shows mortality remains close to 100% through four violations. Mortality monotonically increases based on the number of events at 5+ violations.

When the speeding violations involve speeds of 16-30 MPH over the speed limit, the increase in mortality (SMR) begins at fewer events, as reflected in Table 7. Confidence intervals are included, as multiple violations are rare and not statistically credible, when a 95% confidence interval is applied.

Mortality increases continuously when speeding violations are 31 MPH or higher. In Table 8, at two events, the confidence interval crosses 100%, suggesting results are not credible. If a 90% confidence interval had been chosen, the results would have remained statistically significant.

Figure 3 suggests that mortality does not increase over baseline until at least five events are registered at lower levels of speeding (1-15 MPH over the limit). When the speeding violations are in the 16-30 MPH range, by three events, mortality has lifted above the baseline. For those whose speed exceeds 31+ MPH over the limit, there is immediate lift over the baseline. As degree of speeding increases, fewer individuals exhibit multiple events, thus the lines in Figure 3 are shorter for higher degrees of speeding.

Police pursuing speeding vehicle

Table 6 – Violation Speed 1-15 MPH

No. Events	Exposure-yrs	Deaths	Obs/US Pop	SMR	LL	UL
0	27,925,470	139,558	73%	100%	99%	101%
1	4,461,822	12,241	73%	100%	98%	102%
2	610,396	1,388	75%	103%	98%	109%
3	101,358	191	69%	94%	81%	109%
4	22,508	41	68%	93%	67%	126%
5	4,219	11	94%	129%	64%	231%
6	1,441	5	143%	196%	63%	457%
7	257	2	222%	305%	34%	1100%
8	101	1	333%	457%	6%	2542%

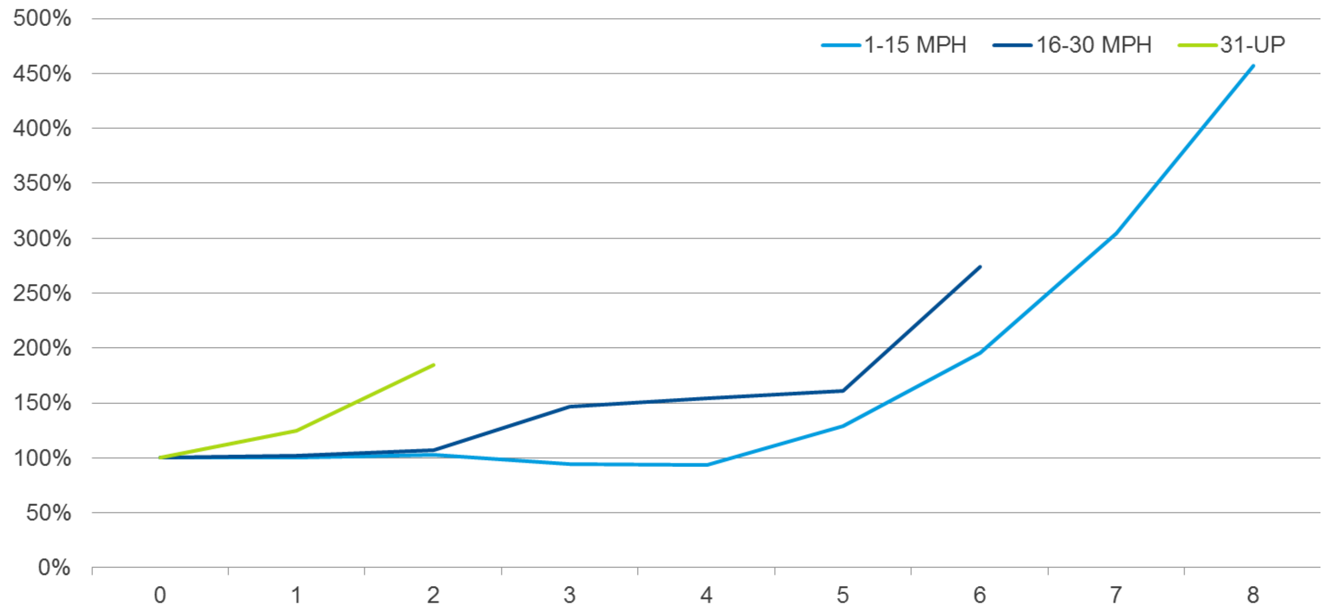
Table 7 – Violation Speed 16-30 MPH

No. Events	Exposure-yrs	Deaths	Obs/US Pop	SMR	LL	UL
0	27,925,470	139,558	73%	100%	99%	101%
1	2,933,542	7,221	75%	102%	100%	105%
2	322,833	650	78%	107%	99%	116%
3	41,641	98	107%	146%	119%	178%
4	7,860	18	113%	154%	91%	244%
5	872	2	118%	161%	18%	582%
6	259	1	200%	274%	4%	1525%

Table 8 – Violation Speed 31+ MPH

No. Events	Exposure-yrs	Deaths	Obs/US Pop	SMR	LL	UL
0	27,925,470	139,558	73%	100%	99%	101%
1	177,988	363	91%	124%	112%	138%
2	4,865	12	135%	185%	95%	323%

Figure 3 – Number of Events by MPH



Accidents

To be considered a major accident, the violation code included injury or death occurring at time of event. The violation recipient is presumed responsible for the accident because a ticket was issued. Table 9 outlines mortality for those codes.

Although higher mortality is associated with major accidents, there is less correlation between major accidents and all-cause mortality when compared to that found with DUI, Reckless-Negligent, or Suspension-Revocation violations.

Table 9 – Mortality for Accident Violations

Category	Exposure-yrs	Deaths	Obs/US Pop	SMR
NO VIO	27,925,470	139,558	73%	100%
ACC 0-2 YRS	440,816	1,992	95%	130%
ACC 3-5 YRS	330,232	1,330	85%	117%
ACC 6+ YRS	9,299	48	114%	157%

Combined View

The LexisNexis® Standardized Violation Code mapping includes a series of violation categories that lends itself to additional analysis. Codes beginning with the number 5 are considered major violations. Combining those violations with the research presented here for DUIs, reckless negligent driving, suspensions/revocations, speeding over 30 MPH, and accidents describes the individuals in the major violations category. Individuals with no violations comprise the clean records population used for comparative purposes. The minor violation population is comprised of the remaining individuals who have neither major violations nor clean MVRs.

Mortality patterns are traced over eight years of follow-up (Durations 1-8). The small number of records entering the ninth year precludes analysis of this population. The purpose of this view is to investigate the mortality pattern by duration. The results are further subdivided by three age groups comprised of 17- to 39-, 40- to 59-, and 60- to 85-year-olds at the time of the MVR acquisition. Mortality rates are expressed as both standardized mortality ratios relative to those with no violations (SMR), as well as extra deaths per thousand lives (q-q')1000 which are also referred to as flat extras (FE).

Tables 10 through 13 provide a global view regarding the question of whether or not mortality findings are age independent. If independent, the extra deaths per thousand would be similar across all age bands and the SMRs would vary. If mortality is better represented as an SMR, then the extra deaths per thousand would vary by age, and the pattern of SMRs would be relatively constant across ages. These tables show the flat extras (FEs) vary by age group more than SMRs do.

Figures 4 through 6 show standardized mortality ratios (SMRs) for major violations remain statistically significant (95% confidence interval error bars based on Byar's Approximation to the Poisson) through eight durations for all three age categories.

Table 10 – Mortality by Age Group and Duration

Age Group	MVR Severity	Duration 1					Duration 2				
		Exposure-yrs	Death Sum	Pop Obs/US Pop	SMR A/E	FE (q-q') 1000	Exposure-yrs	Death Sum	Pop Obs/US Pop	SMR A/E	FE (q-q') 1000
17-39	Clean Record	2,177,300	1,374	62%	100%	0.00	2,175,926	1,555	66%	100%	0.00
	Major VIO	407,335	671	143%	232%	0.94	406,664	675	138%	209%	0.86
	Minor VIO	1,679,342	1,505	83%	134%	0.23	1,677,837	1,668	88%	132%	0.24
40-59	Clean Record	1,969,691	5,764	68%	100%	0.00	1,963,927	6,510	71%	100%	0.00
	Major VIO	176,739	1,050	141%	208%	3.08	175,689	1,141	142%	200%	3.25
	Minor VIO	921,146	3,003	77%	114%	0.39	918,143	3,431	82%	115%	0.49
60+	Clean Record	818,019	13,454	75%	100%	0.00	804,565	15,460	80%	100%	0.00
	Major VIO	29,211	625	102%	137%	5.78	28,586	751	116%	145%	8.11
	Minor VIO	207,576	3,086	73%	98%	-0.30	204,490	3,600	80%	100%	-0.07

Table 11 – Mortality by Age Group and Duration

Age Group	MVR Severity	Duration 3 Exposure-yrs	Duration 3 Death Sum	Duration 3 Pop Obs/US Pop	Duration 3 SMR A/E	Duration 3 FE (q-q') 1000	Duration 4 Exposure-yrs	Duration 4 Death Sum	Duration 4 Pop Obs/US Pop	Duration 4 SMR A/E	Duration 4 FE (q-q') 1000
17-39	Clean Record	2,174,371	1,605	65%	100%	0.00	2,047,647	1,506	61%	100%	0.00
	Major VIO	405,989	653	129%	198%	0.80	379,404	643	130%	212%	0.90
	Minor VIO	1,676,169	1,657	83%	128%	0.22	1,569,061	1,589	82%	133%	0.25
40-59	Clean Record	1,957,417	6,931	70%	100%	0.00	1,827,775	6,754	68%	100%	0.00
	Major VIO	174,548	1,202	139%	198%	3.42	160,907	1,126	131%	193%	3.37
	Minor VIO	914,712	3,598	79%	113%	0.46	847,556	3,447	76%	112%	0.43
60+	Clean Record	789,105	16,221	79%	100%	0.00	718,646	15,662	77%	100%	0.00
	Major VIO	27,835	745	110%	139%	7.45	24,886	705	107%	138%	7.83
	Minor VIO	200,890	3,923	82%	103%	0.66	181,723	3,758	80%	104%	0.73

Table 12 – Mortality by Age Group and Duration

Age Group	MVR Severity	Duration 5 Exposure-yrs	Duration 5 Death Sum	Duration 5 Pop Obs/US Pop	Duration 5 SMR A/E	Duration 5 FE (q-q') 1000	Duration 6 Exposure-yrs	Duration 6 Death Sum	Duration 6 Pop Obs/US Pop	Duration 6 SMR A/E	Duration 6 FE (q-q') 1000
17-39	Clean Record	1,656,235	1,235	59%	100%	0.00	1,207,451	900	56%	100%	0.00
	Major VIO	298,416	514	127%	216%	0.92	211,621	330	110%	197%	0.77
	Minor VIO	1,244,832	1,299	80%	136%	0.28	893,118	918	75%	135%	0.27
40-59	Clean Record	1,450,920	5,553	66%	100%	0.00	1,037,354	4,221	65%	100%	0.00
	Major VIO	123,448	812	115%	175%	2.82	86,047	657	124%	192%	3.65
	Minor VIO	656,755	2,911	77%	118%	0.67	459,028	2,089	74%	114%	0.54
60+	Clean Record	543,899	13,107	79%	100%	0.00	367,675	9,147	75%	100%	0.00
	Major VIO	18,136	621	118%	151%	11.51	12,019	378	100%	133%	7.82
	Minor VIO	134,550	2,965	78%	100%	-0.05	89,151	2,177	80%	107%	1.51

Table 13 – Mortality by Age Group and Duration

Age Group	MVR Severity	Duration 7					Duration 8				
		Exposure-yrs	Death Sum	Pop Obs/US Pop	SMR A/E	FE (q-q') 1000	Exposure-yrs	Death Sum	Pop Obs/US Pop	SMR A/E	FE (q-q') 1000
17-39	Clean Record	747,460	577	54%	100%	0.00	297,968	255	56%	100%	0.00
	Major VIO	127,362	241	126%	233%	1.08	50,754	81	101%	179%	0.70
	Minor VIO	549,925	530	67%	123%	0.18	220,355	239	71%	125%	0.22
40-59	Clean Record	635,411	2,680	62%	100%	0.00	251,252	1,116	61%	100%	0.00
	Major VIO	51,416	390	115%	184%	3.45	20,469	163	112%	183%	3.62
	Minor VIO	277,592	1,316	71%	114%	0.59	108,917	571	73%	120%	0.87
60+	Clean Record	214,853	5,706	73%	100%	0.00	80,783	2,208	69%	100%	0.00
	Major VIO	6,888	226	95%	130%	7.50	2,647	105	104%	150%	13.26
	Minor VIO	51,284	1,337	78%	106%	1.52	19,206	528	75%	109%	2.17

Figure 4 – Standardized Mortality Ratios Major Violations Ages 17-39

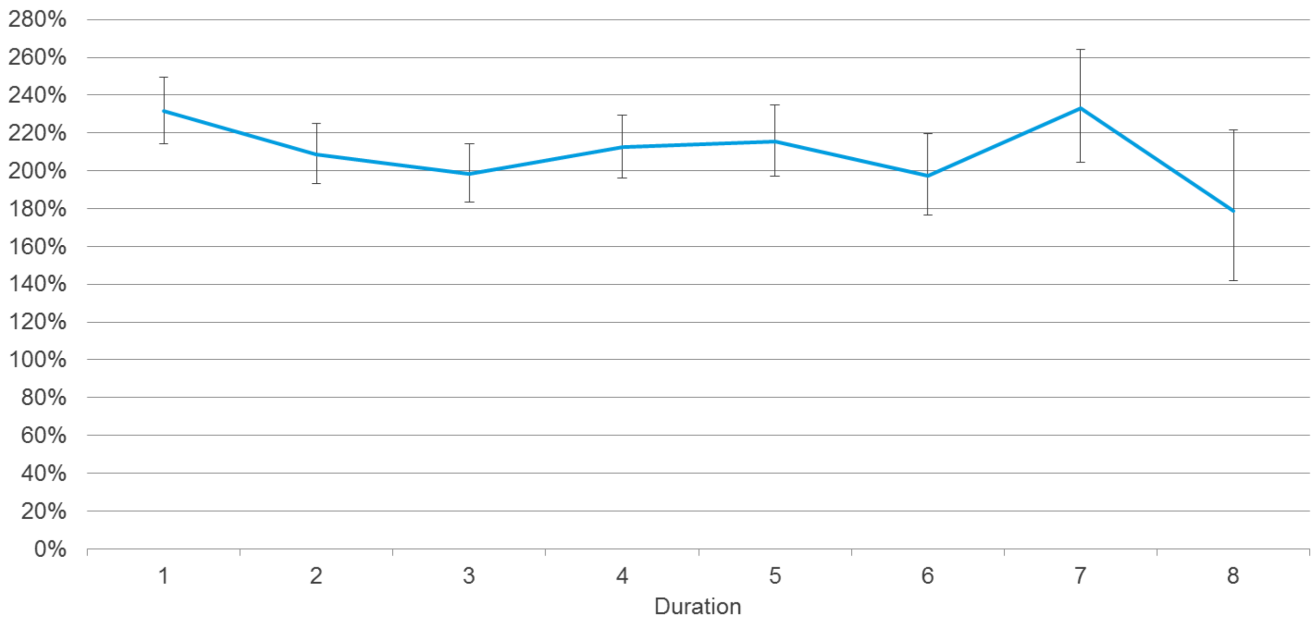


Figure 5 – Standard Mortality Ratios Major Violations Ages 40-59

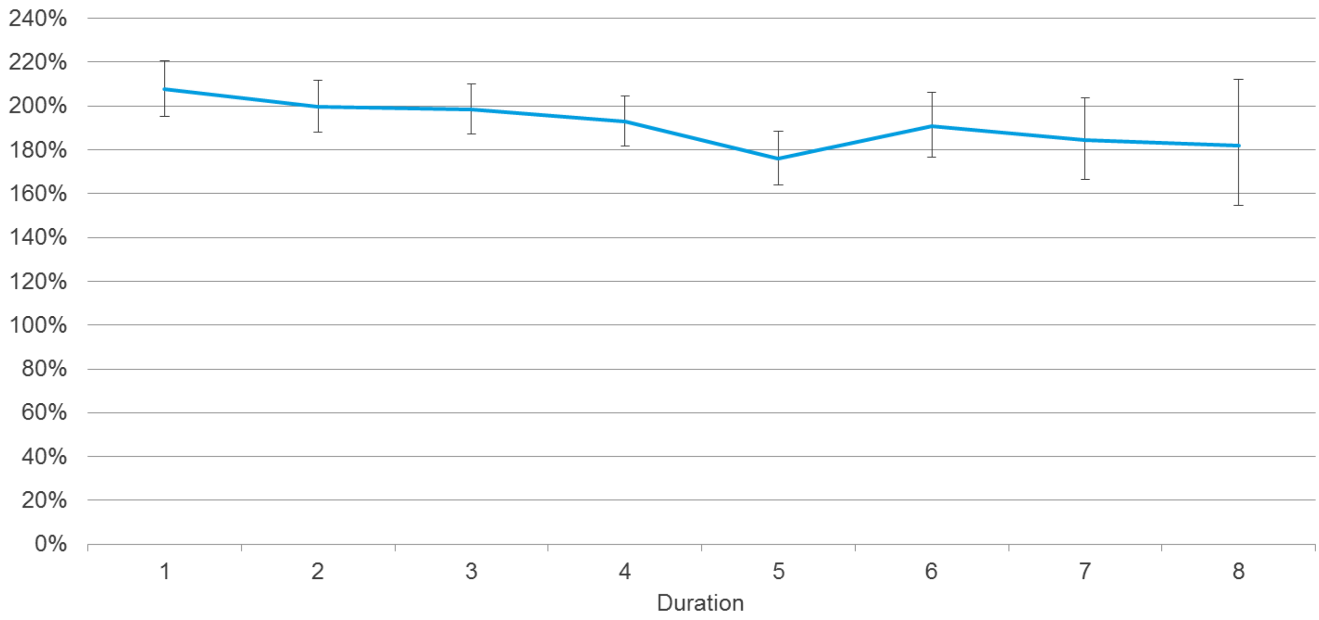
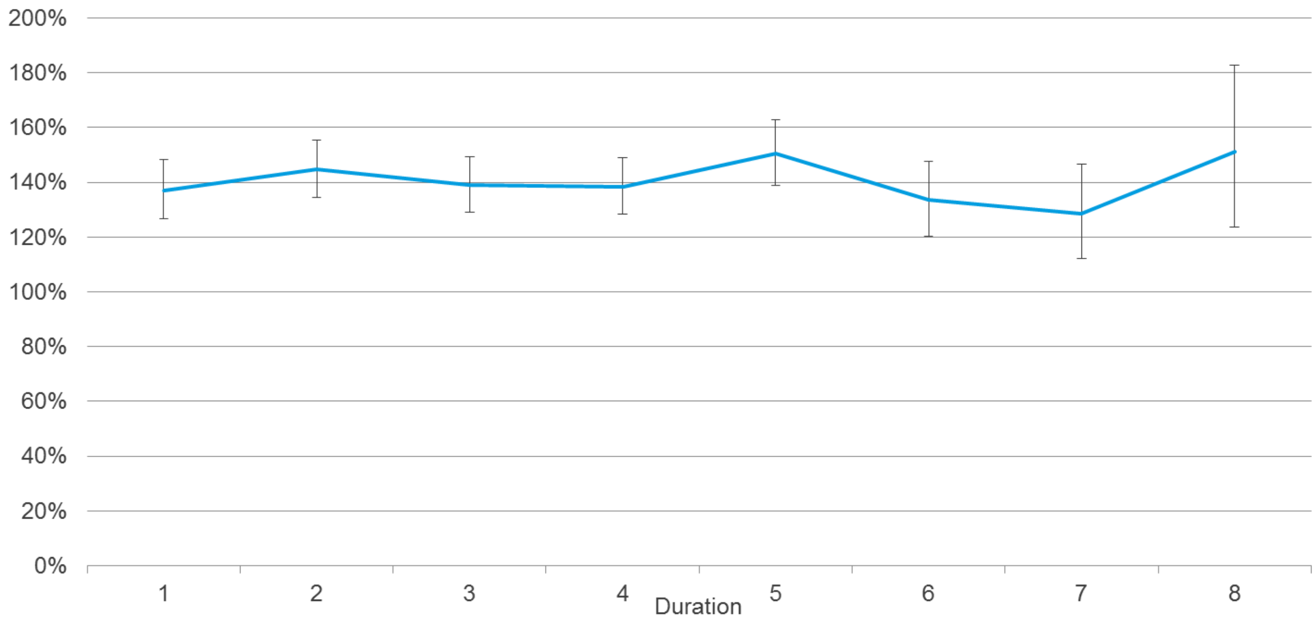


Figure 6 – Standardized Mortality Ratios Major Violations Ages 60+



All Major Violations

The prior section viewed all major violations combined, regardless of when they occurred and recorded results through eight durations. Subsequently, this section looks at mortality by violation based on the event relative to time since MVR acquisition (Table 14).

The data is split into the following categories:

- NO VIO: The record contains no violations
- SOME VIO: Record contains minor violations
- MAJOR VIO DUR 0-2 YRS: The major violation occurred within 2 years of MVR acquisition
- MAJOR VIO DUR 3-5 YRS: The major violation occurred within >2-5 years of MVR acquisition
- MAJOR VIO DUR 6+ YRS: The major violation occurred greater than 5 years from date of MVR acquisition

These individuals are tracked through to the end of the observation period. The mortality for each violation group is compared to the mortality associated with individuals with no violations.

There are two primary themes. First, the excess death rate per thousand lives (q-q')1000 varies by age group. This suggests mortality is not age independent. Secondly, even when the violation occurred more than five years prior to MVR collection, mortality bounded by 95% confidence intervals remains statistically greater than that of those with no violations.

Table 14 – Mortality by Age Group and Violation

Age Group	VIO GRP	Exposure-yrs	Deaths	Obs/US Pop	SMR	(q-q')1000	LL	UL
17-39	NO VIO	12,489,041	9,008	61%	100%	0.00	98%	102%
	SOME VIO	9,514,241	9,409	81%	132%	0.24	130%	135%
	MAJ VIO DUR 0-2 YRS	1,319,747	2,310	140%	229%	0.99	220%	239%
	MAJ VIO DUR 3-5 YRS	769,426	1,183	119%	194%	0.75	183%	206%
	MAJ VIO DUR 6+ YRS	199,204	316	108%	177%	0.69	158%	197%
40-59	NO VIO	11,097,657	39,554	67%	100%	0.00	99%	101%
	SOME VIO	5,105,554	20,375	77%	114%	0.50	113%	116%
	MAJ VIO DUR 0-2 YRS	489,429	3,435	138%	205%	3.59	198%	212%
	MAJ VIO DUR 3-5 YRS	330,265	2,093	123%	182%	2.86	174%	190%
	MAJ VIO DUR 6+ YRS	149,901	1,014	126%	187%	3.15	176%	199%
60+	NO VIO	4,338,772	90,996	77%	100%	0.00	99%	101%
	SOME VIO	1,089,162	21,383	79%	102%	0.41	101%	104%
	MAJ VIO DUR 0-2 YRS	78,159	2,232	109%	142%	8.38	136%	148%
	MAJ VIO DUR 3-5 YRS	51,829	1,334	102%	132%	6.26	125%	139%
	MAJ VIO DUR 6+ YRS	20,264	593	121%	157%	10.67	145%	171%

Protective Value Study

Assumptions are made when constructing any protective value study. Reporting assumptions should be mandatory. Breakeven points can vary considerably, depending upon assumptions used. That said, in reviewing the literature on protective value studies on a variety of topics, it is apparent authors do a good job reporting assumptions used, allowing the reader to attach their own degree of credibility to the results, depending upon how well the assumptions match their expectations. With that philosophy in mind, the following factors have been employed.

One of the most important features of any protective value study is setting the proportion of time the requirement was the source of the finding. These are often referred to by underwriters as surprise debits.

In other words, prior to the receipt of the requirement, these mortality findings were not present and were unknown to the underwriter. They were a surprise finding and the surprise debits are awarded to the requirement. In reviewing the literature, this finding has been described in a number of ways. It may be referred to as the attribution ratio[4], i.e., the proportion of time the finding can be attributed to the requirement as the sole source in finding the impairment. Or, this value has also been called the exclusivity ratio, which describes the proportion of time the requirement exclusively brought value to underwriting by itself[5].

It is not unusual to have this component of a cost benefit study be an unknown factor in the equation. In some instances, different exclusivity factors are chosen to stress test the breakeven point in the analysis. In other studies, a face amount is chosen as the testing threshold and the author solves for the amount of time the test would need to be a surprise finding to justify its use[6].

Hannover Re conducted a study of an insurance applicant population that specifically looked at the question concerning the proportion of time the MVR represented a surprise finding and then compared the answer to the question of driving habits found on the application.

The study was conducted in 2010 and the complete database was comprised of 9,706 applications. Out of this sample there were 79 applicants rated or declined for MVR violations. Of those, 18 (23%) admitted to driving violations on the application. That suggests that 77% of the time the MVR results would be a surprise finding.

Companies intentionally limit the mortality implications for testing so as not to overvalue this side of the equation when conducting cost benefit studies[7]. The hard dollar expenses, for testing, fall to the bottom line at the outset. Mortality savings accrue over years into the future. That's why these mortality findings are recast as present-value figures – to allow for comparison in today's dollars. Lapse and interest rate assumptions must be defined, as they, too, diminish the dollars needed today to pay future claims. These issues are spelled out so that the reader understands that breakeven points calculated from cost benefit studies are created using a number of assumptions. The assumptions are enumerated in the study for purposes of full disclosure and to allow the reader to understand why breakeven points vary based on the assumptions applied.

The mortality rate by type of violation is compared to the mortality rate in the general population for those with no violations. This ratio is used to describe the expected increase in mortality that would be found in an insurance population. The underlying mortality rates associated with an insurance industry mortality table are much lower than those found in the general population mortality table. Applying these mortality ratio expectations to an insurance industry table diminishes the mortality findings expected to ensue and further reduces the mortality benefit side of the cost benefit equation.

The prevalence of major violations by age and gender describes the proportion of time a mortality finding is present. How often would an applicant admit to a major violation when applying for insurance? As noted earlier, Hannover Re's research suggests it would be a surprise finding 77% of the time. But, to reduce the mortality impact, so as not to overvalue the requirement, this analysis will assume 50% of the time the MVR findings would be a surprise.

Other assumptions are of considerable importance as well. Setting the pricing horizon at 10 years means it only accounts for mortality that occurs within 10 years of issue. Extra mortality may exist for more than 10 years. There are suggestions that events occurring 6+ years prior to the date of the MVR inquiry still exhibit extra mortality and that extra mortality, while somewhat attenuated, still persists past 10 years. Many underwriting guidelines presume the predictive ability of MVR violations wears off in less than 10 years. In the spirit of not overestimating the mortality value, a 10-year pricing horizon is chosen. The following assumptions are used in the cost benefit study.

Assumptions

- 100% of the 2008 VBT Select and Ultimate Age Last Birthday (ALB) Smoker Unknown Mortality Table
- 50% of the time the MVR is a surprise finding
- 10-year pricing horizon
- 5% level interest discount rate
- 5% level lapse rate
- $10 cost of test

The standardized mortality rates for major violations are applied to the industry table where discounts for lapses, mortality, survival, and interest rates are factored into the analysis. The breakeven point is derived by finding the life insurance face amount that generates enough mortality dollar savings to offset the cost of each individual test performed. Table 15 describes the breakeven face amount that justifies ordering an MVR, rounded to the nearest $5,000, by age and gender when the MVR cost is assumed to be $10.00. The table shows where the mortality savings, in present-value dollars, equals the cost of the test. Based on all the assumptions described, the face amounts in excess of these figures will produce greater mortality savings than the fixed expense amounts.

Table 15 – Breakeven

Age Group	Female	Male
20-29	135,000	45,000
30-39	100,000	45,000
40-49	55,000	30,000
50-59	50,000	20,000
60-69	45,000	20,000
70-79	60,000	15,000
80-85	55,000	20,000

Study Limitations

This study is based on a large population of individuals that had MVRs collected for a variety of reasons. Some records were the result of automobile insurance inquiries, some were for life insurance, and others obtained for a variety of other reasons. Attempts were made to accurately define those who died, but, there is still a degree of uncertainty as to the accuracy of mortality results presented here. The mortality ratios are broadly looking at differences in mortality based on MVR findings alone. There are, no doubt, other factors not accounted for that would also modify these findings. The resulting statistics are based on all-cause mortality in the general population. Mortality rates in the general population are higher than insured populations that undergo underwriting. Certain driving activities may be correlated with lifestyle behaviors, so there may be indirect correlations to mortality associated with some of the driving activities; however, the data was unavailable and could not be accounted for in this study. As described in the prior section, the protective value breakeven points depend on a number of assumptions. Changing any one of the assumptions would change breakeven points.

Conclusion

The overall data set used for this study is comprised of approximately 8.3 million records with over 200,000 deaths. Using a large population helps to stabilize results for research purposes.

For the violations studied, the strongest correlation with extra mortality was associated with driving while impaired, then suspensions/revocations, followed closely by reckless/negligent driving. Speeding mortality was associated with the degree of speeding in miles per hour (MPH) over the speed limit, in addition to the number of speeding events, although statistical credibility was not met with rare events. Accidents were associated with extra mortality, but did not produce findings as adverse as some other violations reported here.

In general, major violations were associated with increased mortality throughout the study observation period.

Comparing violations to clean records for ages 17-59 produced fairly homogeneous results when viewed as standardized mortality ratios. The excess death rates varied by age which, by definition, suggested an age-dependent baseline was superior in expressing risk.

Thanks to LexisNexis®, for making this study possible and allowing for this view of findings as outlined in this report.

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