2003 Swiss Re Blood Pressure Study of Insured Lives

C. Allen Pinkham,* Brian Ivanovic,† and Marianne E. Cumming‡

Abstract

Blood pressure, one of the most important mortality risk factors, is a common life insurance underwriting tool for classification of preferred, standard, and substandard risks. In order to assess changes in mortality risk associated with blood pressure since the last major intercompany study, Swiss Re's Research & Development and Medical Departments conducted a longitudinal study of blood pressure readings collected at the time of policy issue. Mortality risk associated with different blood pressure levels on nearly 300,000 life insurance policies issued without any other ratable impairments was evaluated. The study cohort was formed by policies issued from 1975 through 2001, which generated over 8,600 claims within the study period. Univariate and bivariate blood pressure mortality results are shown along with results for other key covariates (sex, smoking status, issue year period, policy duration, and cardiovascular family history) for a subset of the cohort that had blood pressure readings of 120/80 mm Hg or lower.

1. Introduction

Blood pressure has been used as an underwriting factor in life insurance for nearly a century. Some life insurance companies were recording blood pressures as early as 1906, even before blood pressure machines were used in medical practice. Incorporation of systolic blood pressure readings became common practice in the industry in 1911, and the recording of both systolic and diastolic blood pressures became common by 1918. In 1925, the Joint Committee of the Association of Life Insurance Medical Directors of America and the Actuarial Society of America published the first mortality study of blood pressure in insured lives (ALIMDA and ASA 1925).

In this 1925 study, mortality was favorable in individuals with "under the average" systolic blood pressure (94%), while those with "over the average" blood pressure had a risk of 114% (expressed as a ratio of the mortality in the average blood pressure group); see ALIMDA and ASA (1925, p. 33). Intercompany blood pressure studies on insured populations followed in 1939 (ASA and ALIMDA 1940), 1959 (SOA 1959), and 1979 (SOA and ALIMDA 1980). All of these studies noted higher mortality with increased blood pressure.

Large population studies followed, including the Framingham study, which identified elevated blood pressure as a key determinant of increased cardiovascular morbidity risk and premature mortality (Kannel 2000). Numerous additional studies on populations worldwide have drawn similar conclusions.

The deleterious effects of high blood pressure as reported from these studies are numerous. High blood pressure is associated with increased risk of developing coronary heart disease, stroke, congestive heart failure, renal insufficiency, and peripheral arterial disease (Chobanian et al. 2003). The absolute risk of cardiovascular mortality rises progressively with increasing blood pressure levels (McMahon et al. 1990; Stamler, Stamler, and Neaton 1993). Additional factors that increase the absolute risk of high blood pressure include advancing age, presence of other cardiovascular risk factors (including dyslipidemia, diabetes mellitus,

* C. Allen Pinkham, ASA, MAAA, MA, is Director of Applied Research & Development, Swiss Re Life and Health America, Inc., 1700 Magnavox Way, Fort Wayne, IN 46804, allen_pinkham@swissre.com.
† Brian Ivanovic, DO, MS, is Vice President for Applied Research & Development, Swiss Re Life and Health America, Inc., 1700 Magnavox Way, Fort Wayne, IN 46804, brian_ivanovic@swissre.com.
‡ Marianne E. Cumming, MD, MSc, is Second Vice President and Medical Director, Swiss Re Life and Health America, Inc., 1700 Magnavox Way, Fort Wayne, IN 46804, marianne_cumming@swissre.com.

smoking, and family history of cardiovascular disease), and evidence of left ventricular hypertrophy or end-organ damage (cardiac, cerebral, renal, and/or peripheral vasculature).

Since the last major intercompany blood pressure study, variation in population prevalence of cardiovascular risk factors and therapeutic advances in the management of cardiovascular disease and hypertension have resulted in changes in the influence high blood pressure has on mortality. Mortality associated with lower levels of blood pressure, including high normal blood pressure, has been identified (Vasan et al. 2001). Public awareness of the dangers of abnormal blood pressure and of available treatment has increased. Such changes potentially impact the distribution of blood pressures in the insured and general population and may influence the magnitude of mortality risk over time in both groups. Clinical studies augment, but do not replace, insured lives studies in the understanding of these relationships, as there may be subtle differences specific to insured populations.

Preferred plans have proliferated since the 1979 intercompany study (SOA and ALIMDA 1980) and became prevalent by the early 1990s. Commonly, preferred plans select risks with favorable medical factors including blood pressure, cholesterol and/or cholesterol/HDL ratio, and body mass index, as well as favorable family history. Aviation and hazardous avocation risks are typically excluded from preferred plans.

The current study quantifies the relationship between blood pressure levels and all-cause mortality in an insured lives population. It examines the differentiation of mortality within the standard risk category and the mortality implications across the entire range of blood pressure values. A subset with optimal blood pressures, defined by the National High Blood Pressure Education Program Coordinating Committee (Chobanian et al. 2003) as a systolic 120 mm Hg or lower and diastolic 80 mm Hg or lower, is analyzed separately.

2. METHODS

2.1 Data Issues and Distributions

Life insurance policies issued in the United States between 1975 and 2001 were followed until death, lapse, or policy anniversary in 2002. The study includes 299,933 policies followed for a total of 1,465,034 policy years and resulting in 8,647 death claims. The cohort is approximately 79% male and 21% female, with a similar proportion for claims. Nonsmokers outnumbered smokers, consistent with general population trends. Smoking status was unknown in about 35% of policies. Most of these policies were issued early in the study period, before smoking-distinct policies were routinely available. The vast majority of policies were issued at standard or preferred rates. Substandard policies rated solely for hypertension were included. Policies with other impairments were excluded, thereby reducing the prevalence of comorbidities that may potentially influence the association between blood pressure and all-cause mortality. Further analysis was done on a subset of 118,799 policies with blood pressure readings of 120/80 (mm Hg) or lower at time of issue, followed for a total of 568,409 policy years and resulting in 2,050 death claims. Distributions (Table 1) and basic statistics (Table 2) are shown for key covariates, measured at time of policy issue.

Mean age at issue is about 42. The relatively small number of policies at older ages reflects the high number of ratable impairments other than hypertension in these age groups. Many policies contribute long follow-up times, as the majority of the policies were issued in the first half of the study and the study period is over 25 years. However, mean policy duration (average follow-up time) is just over five years due to the effect of lapses.

Adverse family history, defined as any clinically diagnosed cardiovascular disease or death in parents or siblings prior to age 60, occurred in 8% of the study cohort. Neutral family history, where family history is either unknown or the insured's parents are not yet 60, occurred in 50%. Family history was favorable in the remaining 42%.

2.2 Mortality Ratio Calculations

The 1975–1980 SOA Basic Select and Ultimate Tables (75–80 tables) were used as baseline mortality for the calculation of expected deaths, given the early issue years of most of the policies.[1] Mortality ratio results were greatly influenced by the smoking status and issue year distributions. Consequently, adjustments for smoking status (when

[1] Exposure was calculated on a seriatim basis, crediting the exact proportion of the policy year exposed for lapses.

Table 1
Data Distributions

	Exposure Number	Distribution by Policies	Distribution by Claims
Total	1,465,034	299,933	8,647
Female	342,740	21.1%	22.2%
Male	1,122,294	78.9	77.8
Nonsmoker	738,196	49.3	40.6
Smoker	202,464	15.8	20.2
Unknown	525,375	34.9	39.2
Issue age 14–49	992,228	72.5	29.9
Issue age 50–59	322,033	19.5	34.4
Issue age 60–69	133,395	7.1	29.4
Issue age 70+	17,378	1.0	6.3
BP rating none	1,450,189	99.7	97.7
BP rating Tables A–D	13,734	0.3	2.2
BP rating Tables E+	1,111	0.0	0.1
Issue yr 1975–84	1,115,950	78.9	86.6
Issue yr 1985–94	339,801	20.1	13.3
Issue yr 1995–2001	9,282	1.0	0.2
FH unfavorable	115,298	8.0	8.5
FH neutral	723,063	50.5	47.8
FH favorable	626,673	41.5	43.7
Systolic 80–140	1,312,801	89.6	78.5
Systolic 141–60	133,897	9.0	18.0
Systolic 161+	18,336	1.4	3.5
Diastolic 50–87	1,247,098	84.5	79.3
Diastolic 88–92	141,949	9.6	13.3
Diastolic 93+	75,987	5.9	7.4

known) and for issue year were used to diminish confounding of the results by these variables. Smoking status was not known for most of the oldest policies, from a time period when the 75–80 tables appropriately reflected the smoking proportion in this era. Smoking status was known, and could be adjusted for, in the later policies when the smoker proportion had dropped. Smoking adjustment factors, separate factors for smokers and nonsmokers by gender and age, are based on our pricing factors from the early 1980s, which represents roughly the midpoint of the experience period. The issue year factors, by gender, are intended to control for secular improvements in mortality throughout the study period and adjust for any changes in expected mortality attributable to insured population fluctuations because of market pressures. Issue year factors are based on our actual experience of standard policies for issue years with credible experience and projections for the last several issue years without credible experience. Policies issued in preferred plans were treated the same as all other policies, without further adjustments to lower the mortality expectation.

For the cause of death (COD) results, additional factors, based on actual claim COD distributions by gender, duration group, and age group, were used to split claims into four primary cause categories: circulatory, neoplasms, violent deaths, and all other causes.

The detailed mortality ratios of actual to expected deaths include 90% confidence intervals (CIs) and are shown in the Appendices. The CIs by number of deaths are calculated assuming a

Table 2
Data Statistics

	Mean	5th Percentile	25th Percentile	Median	75th Percentile	95th Percentile
Follow-up time (yrs)	5.2	0.3	1.4	4.0	7.1	16.0
Issue age (yrs)	42.3	25	34	41	50	62
Issue year (yrs)	1,981.6	1,975	1,978	1,980	1,984	1,992
Systolic BP (mmHg)	124.1	102	115	122	132	148
Diastolic BP (mmHg)	77.9	60	70	80	84	93

Poisson distribution for the deaths using Byar's approximation, as shown in Breslow and Day (1987). CIs by amount of claim also were calculated using the technique described in Panjer (1980). CIs by number of claims are much smaller than those by amount due to the additional variability of policy amounts.

Results presented primarily focus on ratios by number of claims. Detailed results, including exposures, actuals, expecteds, and mortality ratios by number and amount with CIs, are included as Appendices. Results are displayed as figures, where each mortality ratio is shown as a horizontal tick mark on a vertical bar representing the range of its 90% CI. All figures show mortality ratios by number of claims.

3. RESULTS

3.1 Univariate Blood Pressure Mortality Results

Mortality ratio results by systolic blood pressure are presented in Figure 1. Figure 2 shows mortality ratio results by diastolic blood pressure. Both figures demonstrate increasing relative mortality with increasing blood pressure. Statistically significant differences in mortality are demonstrated within the normal systolic and diastolic blood pressure ranges. At the lowest systolic blood pressure cutpoint (80–89), the claims ratio point estimate is somewhat higher than the point estimate for the next systolic blood pressure cutpoint. The suggestion of increased mortality at low systolic blood pressures is suggestive of a J-shaped mortality relationship. A J-shaped mortality relationship was not found with diastolic blood pressure. The CI by-amount results are consistent with the CI by number results, albeit with wider CIs (see Appendix A).

3.2 Bivariate Blood Pressure Mortality Results

There is a general upward trend in the mortality risk as systolic blood pressure increases, for each diastolic blood pressure level (see Appendix B). However, a clear trend in the mortality risk as diastolic blood pressure increases within any of the systolic blood pressure groups is not seen.

Figure 1
Systolic Blood Pressure A/E

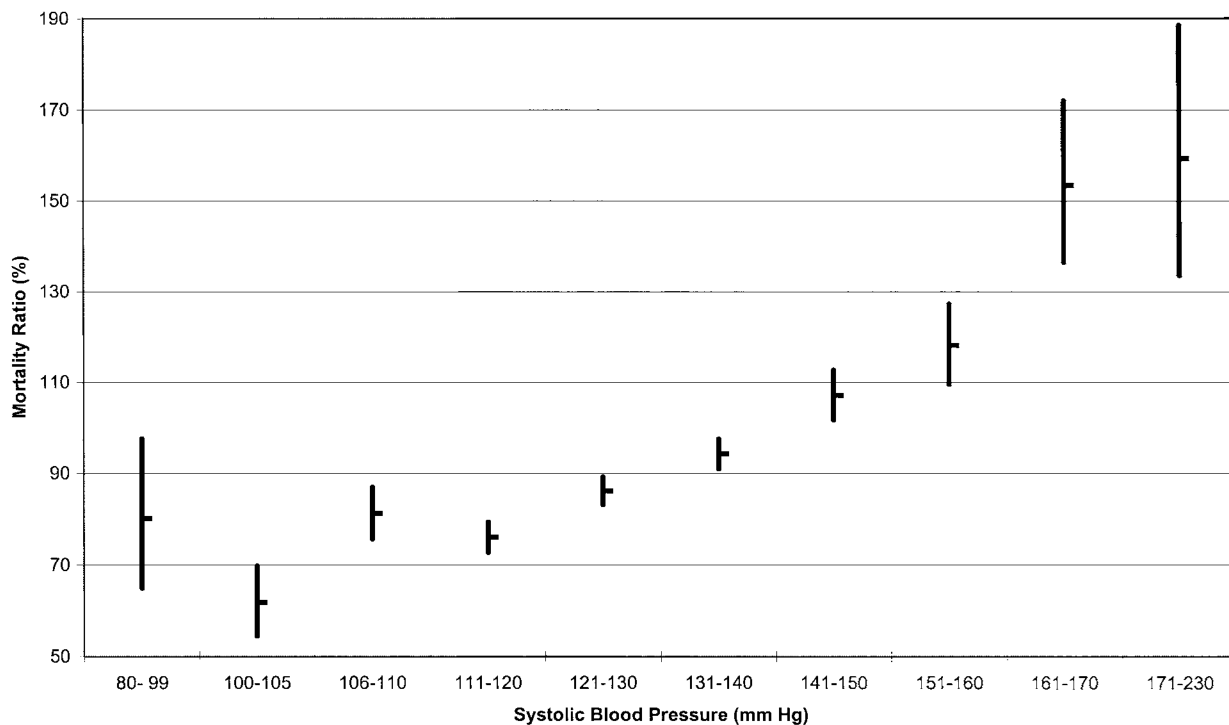


Figure 2
Diastolic Blood Pressure A/E

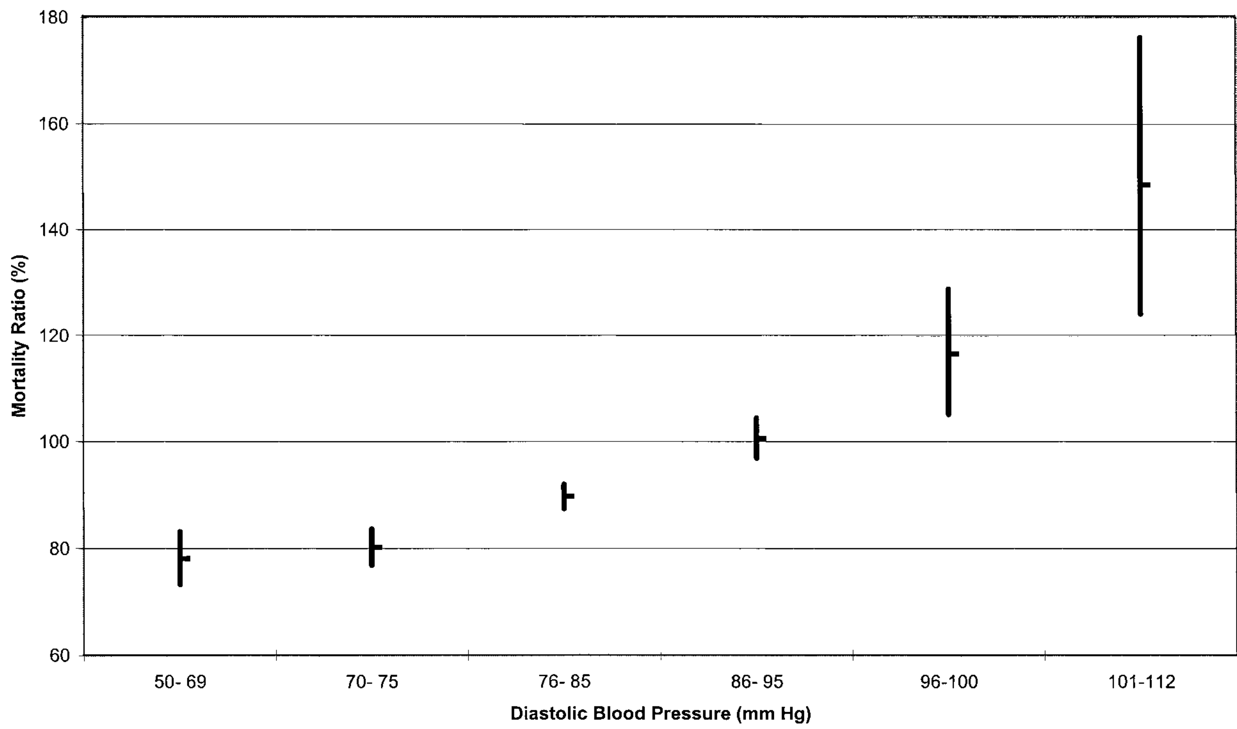
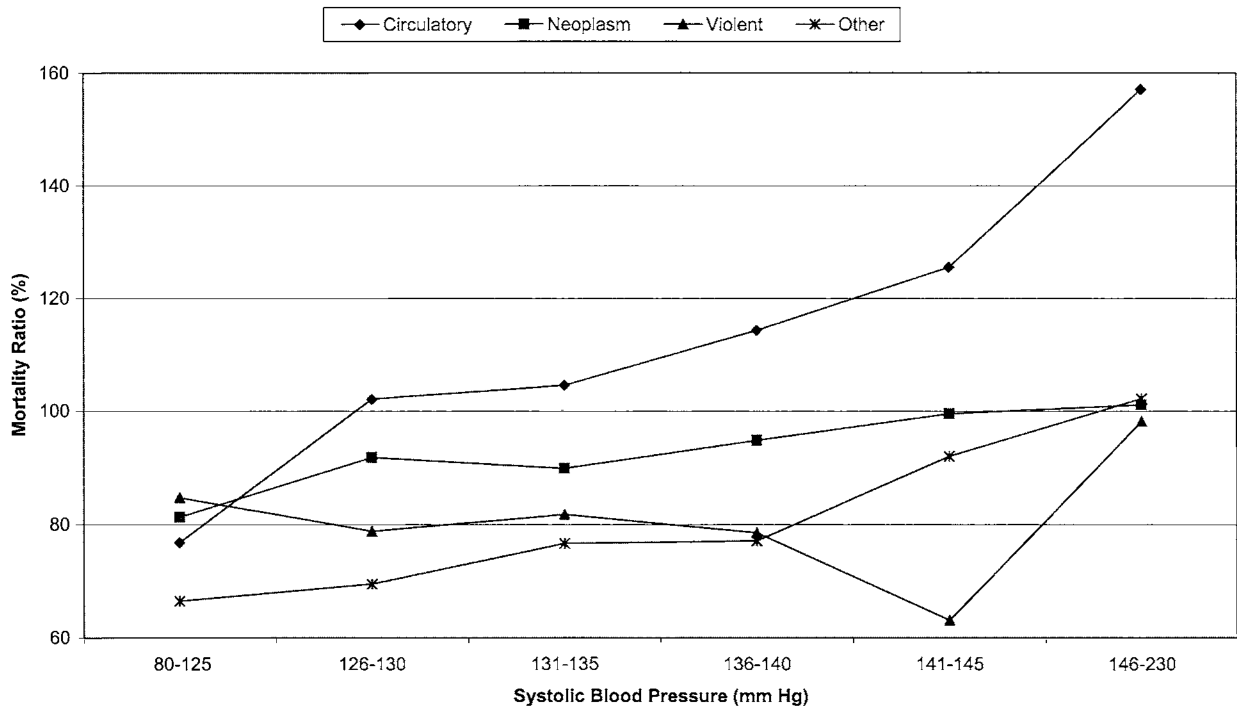


Figure 3
Systolic Blood Pressure A/E by COD



3.3 COD Specific Mortality Results

COD specific mortality ratio results by systolic blood pressure group are shown in Figure 3. The clear pattern of increasing risk with increasing systolic blood pressure is consistent with the known association between elevated blood pressure and circulatory disease. An increasing pattern for neoplasm deaths is demonstrated but less pronounced. A similar relationship is seen with diastolic blood pressure and circulatory and neoplasm deaths (see Appendix C).

3.4 Mortality Results on a Subset with Optimal Blood Pressure

A subset with optimal blood pressures of 120/80 mm Hg or lower was evaluated for other covariates with potential mortality implications in the present preferred plan environment. Policies were not necessarily issued on a preferred basis, although these blood pressures generally meet current preferred plan criteria. The subset was selected solely on blood pressure readings without considering other preferred criteria. Many policies were issued before preferred plans became prevalent and before many preferred criteria were obtained for underwriting. As expected, the overall mortality ratios were better than those for the entire cohort (76% versus 90% by number and 72% versus 92% by amount).

Mortality ratios by gender and smoking status group are shown in Figure 4. Female nonsmokers have the most favorable ratio although their by-amount result is not nearly as favorable relative to the by-amount results for the other groups (see Appendix D). Mortality differences in the other groups are not statistically significant. Mortality results by age group are shown in Figure 5. The two oldest age groups (60–69 and 70+) demonstrated lower relative mortality compared to the younger ages. Relative mortality is highest in the youngest age group (14–29) compared to the other age groups. Similar patterns are seen in the by-amount results (Appendix D).

Figure 6 shows the result by issue year group with substantial improvement in experience in the later study period. Mortality ratio for the 1985 through 1989 issue years is less than 89% of the overall ratio, and for the issue years after 1989, it is less than 75% of the overall ratio. Trends by policy duration are shown in Figure 7. Relative mortality decreases as policy duration

Figure 4

Gender/Smoking A/E Blood Pressures 120/80 (mm Hg) or Lower

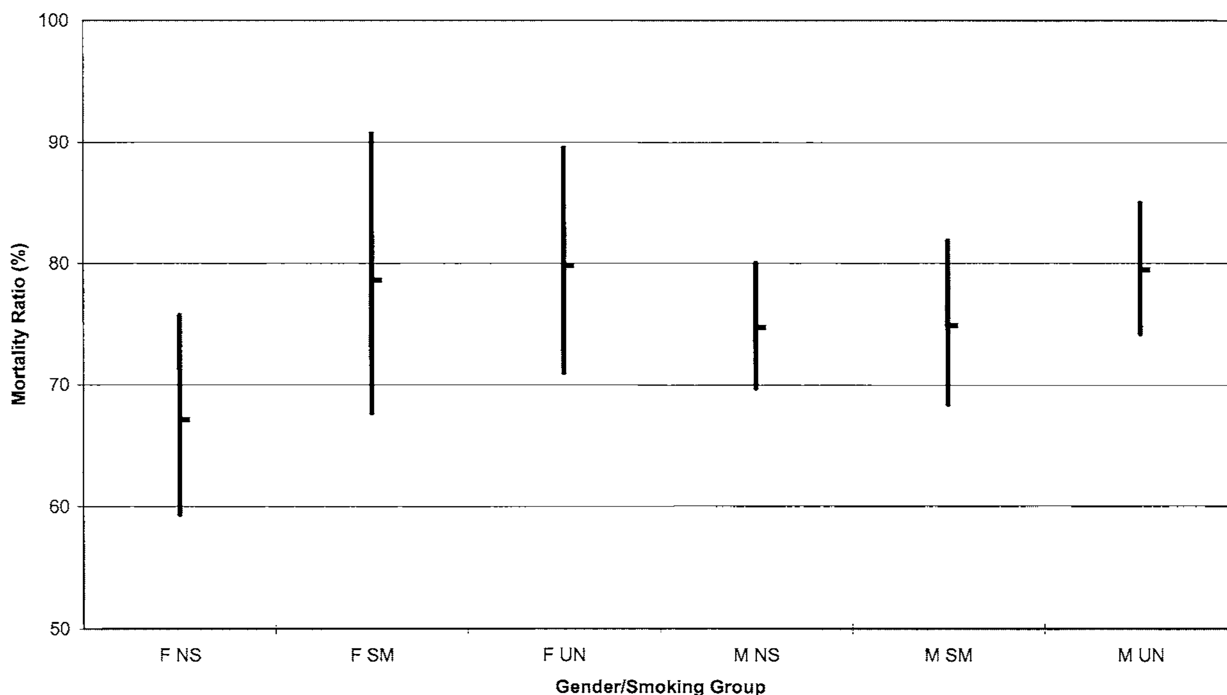


Figure 5
Age Group A/E Blood Pressures 120/80 (mm Hg) or Lower

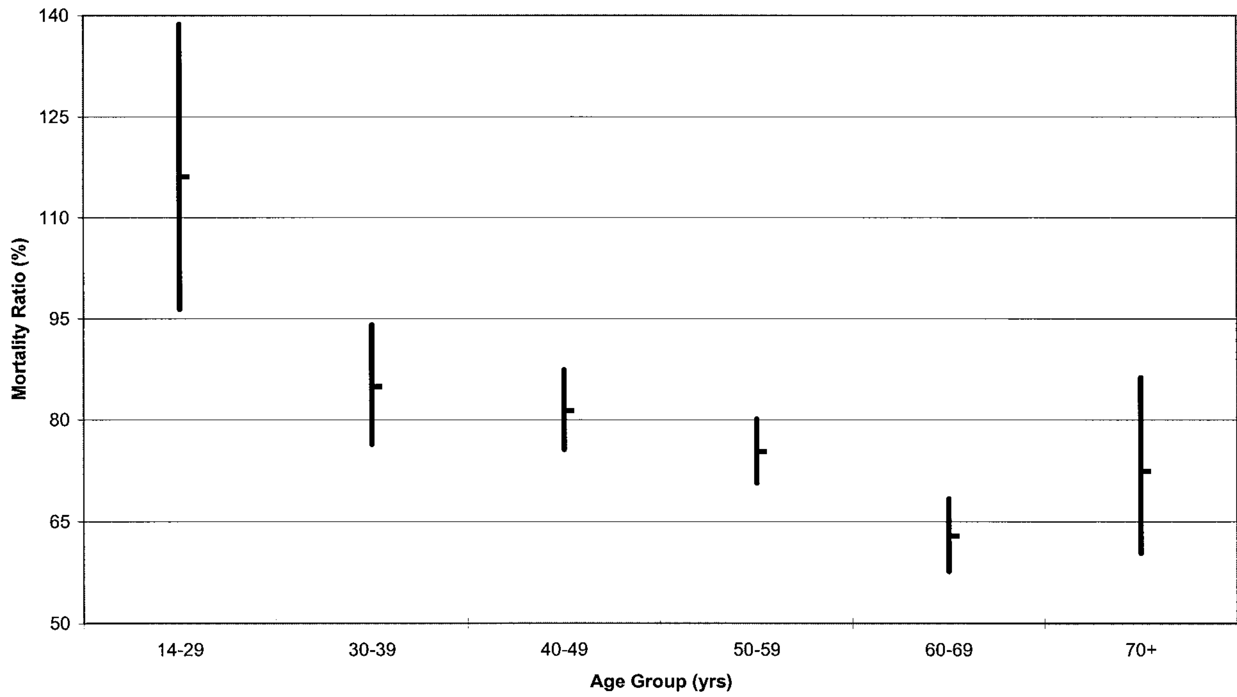


Figure 6
Issue Year Group A/E Blood Pressures 120/80 (mm Hg) or Lower

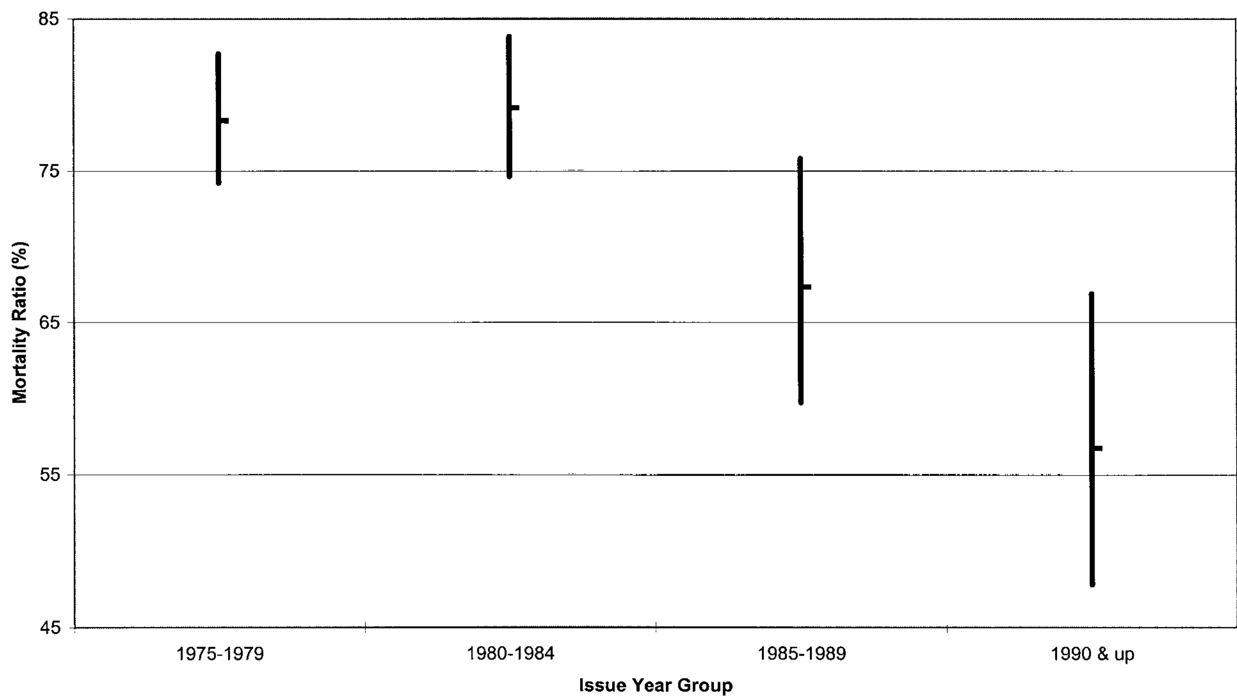
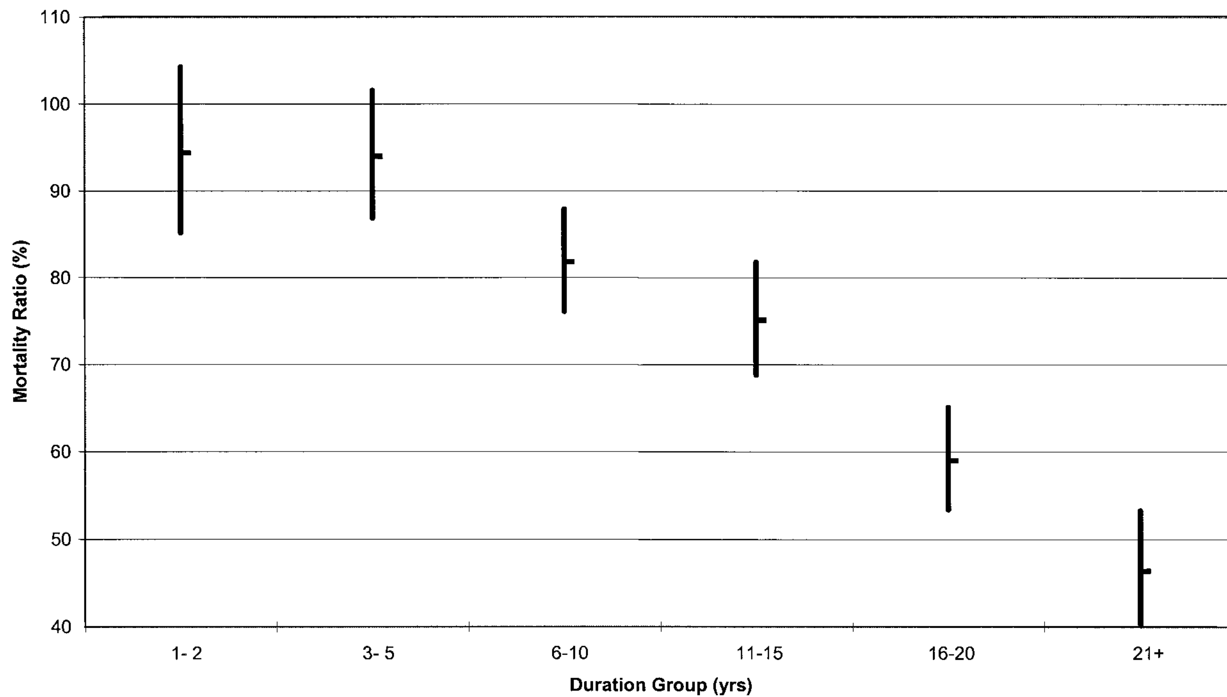


Figure 7
Duration Group A/E Blood Pressures 120/80 (mm Hg) or Lower



lengthens. Mortality ratios for groups with the longest durations of 16–20 and over 21 years are particularly low relative to the other groups (78% and 61% of the overall ratio, respectively).

Adverse family history was a significant predictive factor for increased mortality risk (see Figure 8), even with optimal blood pressure. Relative mortality was 113% compared to the neutral group. Favorable family history was predictive of decreased mortality risk, with relative mortality as 93% of the neutral group.

4. DISCUSSION

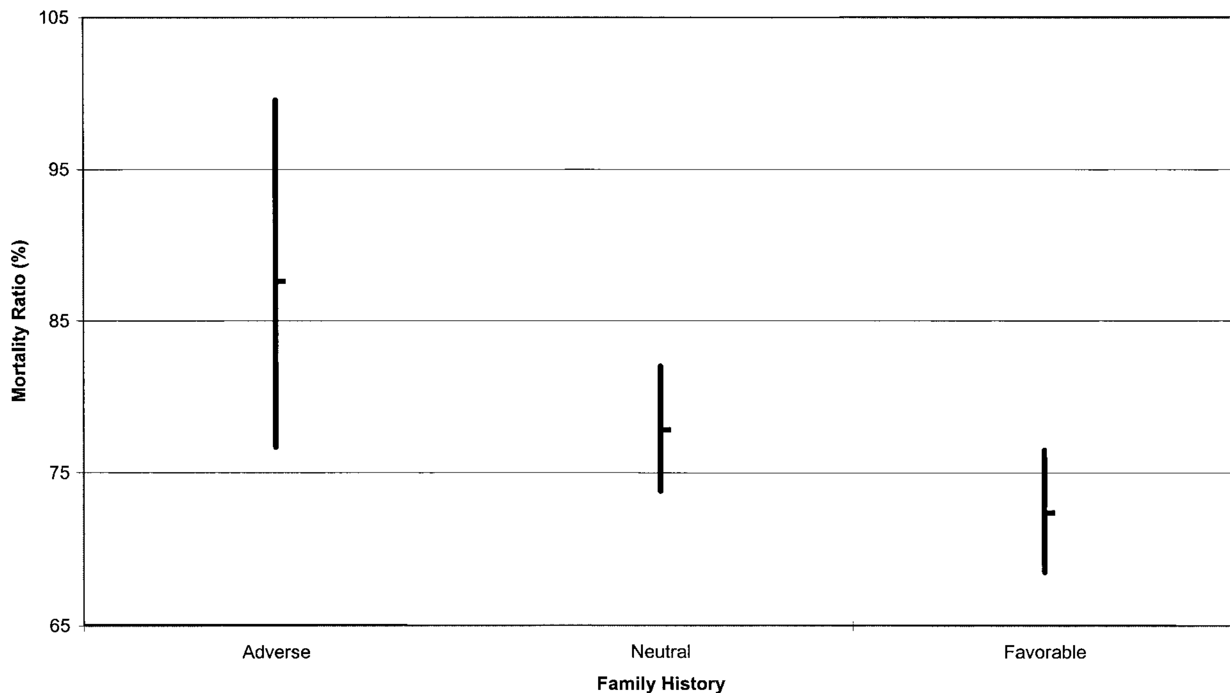
Swiss Re's internal blood pressure study demonstrates the importance of increasing blood pressure as a mortality risk factor in a life insurance population. Results are consistent with prior intercompany insurance studies[2] on the mortality risks associated with elevated blood pressure and are consistent with numerous clinical studies also finding increased mortality (see, e.g., Miura et al. 2001; Perry et al. 2000; Stamler, Stamler, and Neaton 1993; Strandberg et al. 2001; Port et al. 2000; Psaty et al. 2001; and Boshuizen et al. 1998). The present study identifies a graded increase in mortality at blood pressures below levels usually rated. These findings have potential pricing and selection criteria implications, especially for preferred plans.

Our study also identifies a tendency toward increased mortality in policyholders with systolic blood pressures less than 100 mm Hg relative to a higher systolic blood pressure band. Low systolic blood pressure may be an indicator of cardiovascular disease not identified at the time of underwriting. Similar findings have been reported in the clinical literature cited above.

Mortality risk in a bivariate systolic and diastolic blood pressure matrix increases with increasing systolic blood pressure level for each diastolic level and is consistent with limited clinical literature (see Appendix B). The strength of the relationship between systolic blood pressure and mortality appears more consistent than the relationship with diastolic blood pressure and is con-

[2] While the groupings have not been the same in all the prior intercompany studies, they all show similar mortality trends by systolic and diastolic. See pages 33 (systolic) and 35 (diastolic) in the ALIMDA and ASA (1925) study, page 13 in the ASA and ALIMDA (1940) study, pages 133 (male) and 142 (female) in the SOA (1959) study, and page 65 in the SOA and ALIMDA (1980) study.

Figure 8
Family History A/E Blood Pressures 120/80 (mm Hg) or Lower



sistent with the clinical literature. The Chicago Heart Association Detection Project in Industry study, a large prospective study of Chicago-area workers screened from 1967 to 1973, followed more than 12,000 men and 9,000 women ages 35 to 64 years for an average of 15 years (Stamler, Stamler, and Neaton 1993). All-cause mortality was found to increase with increasing systolic blood pressure within the diastolic blood pressure categories. Similarly, all-cause mortality increased with increasing diastolic blood pressure in several but not all systolic blood pressure categories. Another study documents similar findings for an older population (Glynn et al. 2000).

While increases in cardiovascular mortality would be expected in a group with suboptimal blood pressure, the finding of increased cancer mortality is noteworthy (Figure 3). Association between hypertension and increased rates of renal cell cancer has been reported in the clinical literature. Renal cancers were diagnosed in 895 men in a study of almost 364,000 Swedish men (average age 44 years at study entry, followed for an average of 16 years). Higher systolic ($p < 0.007$) and diastolic ($p < 0.001$) blood pressure were independently associated with long-term risk of renal cell cancer. A role for angiogenic and other growth factors associated with hypertension in renal carcinogenesis has been postulated. Individuals with elevated blood pressure are more likely to have other cardiovascular risk factors, including obesity, elevated lipids, and physical inactivity, which are associated with increased cancer risk (Chow et al. 2000).

The more favorable mortality observed in female nonsmokers in the optimal blood pressure cohort is consistent with the clinical literature (Figure 4). Women develop circulatory disease at later ages than males, and circulatory disease risk is lower in nonsmokers compared with smokers (Wilson et al. 1998). Lower mortality in older age groups with optimal blood pressure represents a favorable mortality risk group compared with their peers (Figure 5). These individuals most likely had ideal blood pressures throughout their lives.

Younger individuals with optimal blood pressure appear to have increased mortality risk. Although risk for future blood pressure elevations with increased mortality exists, this observation is likely an artifact of the study era. Younger individuals have a greater risk of death due to noncardiovascular causes, particularly violent deaths (Arias et al. 2003). During the study, HIV and AIDS were

significant causes of death. Relative mortality ratios may be elevated because baseline mortality is based on experience prior to the AIDS epidemic. Also, the vast majority of young insured individuals have optimal blood pressures, with little differentiation between optimal and average blood pressures.

Optimal blood pressure results by issue year demonstrate substantial improvement in experience later in the study period (Figure 6). Since the mortality ratios have been controlled for issue year, this finding cannot be simply attributed to mortality improvement over time. One explanation is the shorter average duration of follow-up, which progressively diminishes in successive issue year groupings. Deleterious effects of suboptimal blood pressure take time to manifest, especially in a cohort issued standard policies that is believed to be free of disease. Population-wide improvements in cardiovascular health and treatment over the past three decades could contribute to these observations. This is illustrated by a recent decreasing trend in the proportion of deaths due to circulatory causes in our overall claim block. Finally, the better overall insurance risk associated with preferred plans—including additional favorable factors besides blood pressure—may explain better experience.

In the optimal blood pressure subset, the decrease in relative mortality with longer policy durations may be a by-product of an exponentially increasing expected death rate coupled with a lower mortality risk based on their favorable risk characteristics at the time of policy issue (Figure 7). Optimal blood pressure at the time of underwriting may confer longstanding mortality benefits to insured groups. An additional explanation for some of the favorable mortality results in the duration groups 16–20 and 21+ is the discontinuity in the mortality rates in the 75–80 tables after the select period ends in duration 15 and the ultimate rates begin to be used. For this cohort with optimal blood pressures, the selection effect does not appear to have worn off by duration 15. Additionally, the slopes of the mortality rates by duration likely have changed over time, with the SOA 1985–90 and 1990–95 tables having different relationships by duration than the 75–80 tables.

The statistically significant association between positive family history and increased mortality within the optimal blood pressure cohort is supported by limited clinical literature (Figure 8). Family history is a significant contributor to coronary heart disease risk, and its relative contribution increases substantially, especially in low-risk populations (Myers et al. 1990).

A variety of factors may influence results of the present study and the magnitude of the calculated mortality ratios. The study cohort is made up primarily of individuals with low probability of preexisting disease who were issued policies at standard or preferred rates. Pricing was adjusted to standard, and not adjusted further for preferred issued policies. This resulted in some analyses with mortality substantially below 100%. The relatively short average policy duration may influence results. The deleterious morbidity and mortality effects of elevated blood pressure take time to manifest. In a standard preferred population with a low preexisting disease burden, a shorter follow-up period would likely reduce the magnitude of mortality observed. Another consideration is the potential influence of selective policy lapse with high policy turnover.

5. CONCLUSION

The 2003 Swiss Re Blood Pressure Study contributes to the historical role of the insurance industry in the identification of mortality associated with elevated blood pressure. The present study demonstrates an association between increasing blood pressure and mortality in an insured lives cohort composed primarily of policies issued at standard or preferred rates. Elevated blood pressure is significantly correlated with increased circulatory system deaths and modestly correlated with cancer deaths. The 1979 Blood Pressure Study showed that slight elevations in blood pressure were associated with higher mortality (SOA and ALIMDA 1980, table 32).

The present study provides additional information demonstrating increased mortality with increasing blood pressures in a predominately standard and preferred issued population. Its identification of increased mortality identified for blood pressure levels below the usual clinical definition of hypertension is important for underwriting and pricing preferred plans, as the expected mortality in preferred cohorts is priced to be substantially lower than average or residual standard products. Blood pressure continues to be an important insurance underwriting and pricing factor.

Appendix A

2003 Swiss Re Blood Pressure Study
Univariate Summary

		Exposed		Expected		Actual		A/E (%)	90 C.I.		A/E (%)	90 C.I.	
Variable Group	Policies Contributing	Policy Years	(1,000s)	Deaths	Amt	Deaths	Claims	Number	Number	Number	Amt	Amt	Amt
Total	299,933	1,465,033.9	$217,000,824	9,609.1	$931,416,732	8,647	$857,234,610	90.0	88.4	91.6	92.0	86.7	97.7
Sys. BP = 80–99	6,017	29,027.0	5,107,873	87.4	10,268,841	70	15,115,184	80.1	65.0	97.6	147.2	71.7	300.6
Sys. BP = 100–105	16,328	77,080.6	13,956,282	294.6	34,813,052	182	11,552,775	61.8	54.5	69.8	33.2	22.9	46.1
Sys. BP = 106–10	33,292	158,481.8	27,372,646	709.5	86,562,311	576	66,687,150	81.2	75.7	87.0	77.0	60.6	96.3
Sys. BP = 111–20	75,658	363,669.5	59,817,503	1,901.1	211,141,147	1,444	179,125,245	76.0	72.7	79.3	84.8	75.0	95.7
Sys. BP = 121–30	80,846	396,782.9	60,111,856	2,536.5	265,824,040	2,184	235,880,584	86.1	83.1	89.2	88.7	79.3	99.3
Sys. BP = 131–40	56,477	287,758.7	35,671,817	2,475.7	213,663,391	2,332	227,796,552	94.2	91.0	97.5	106.6	94.8	119.7
Sys. BP = 141–50	19,401	97,346.7	10,123,295	986.1	71,241,125	1,056	68,655,449	107.1	101.7	112.7	96.4	80.7	114.6
Sys. BP = 151–60	7,700	36,550.5	3,100,413	421.7	26,231,774	498	38,705,432	118.1	109.6	127.2	147.6	111.4	194.7
Sys. BP = 161–70	2,688	12,057.6	1,198,698	136.2	8,056,376	209	8,967,139	153.4	136.5	172.0	111.3	67.1	314.8
Sys. BP = 171–230	1,526	6,278.6	540,440	60.3	3,614,675	96	4,749,102	159.3	133.6	188.6	131.4	72.6	210.2
Dias. BP = 50–69	41,335	196,406.4	28,713,407	874.1	82,124,335	683	75,763,424	78.1	73.3	83.2	92.3	72.7	116.6
Dias. BP = 70–75	64,799	316,782.2	50,589,024	1,895.5	188,423,292	1,521	135,323,557	80.2	76.9	83.7	71.8	62.9	81.7
Dias. BP = 76–85	133,672	663,809.4	102,198,781	4,638.7	466,036,346	4,161	416,367,931	89.7	87.4	92.0	89.3	82.2	97.1
Dias. BP = 86–95	49,349	243,919.2	31,152,512	1,905.8	171,921,451	1,918	195,147,385	100.6	96.9	104.5	113.5	100.1	128.6
Dias. BP = 96–100	7,624	33,090.0	3,491,036	232.4	18,836,338	271	24,204,520	116.6	105.2	128.9	128.5	83.6	212.0
Dias. BP = 101–12	3,154	11,026.7	856,063	62.6	4,074,971	93	10,427,794	148.5	124.1	176.3	255.9	157.9	393.6

Appendix B

2003 Swiss Re Blood Pressure Study
Bivariate Summary

Variable Group	Policies Contributing	Exposed		Expected		Actual		A/E (%)	90 C.I.		A/E (%)	90 C.I.	
		Policy Years	(1,000s)	Deaths	Amt	Deaths	Claims	Number	Number	Number	Amt	Amt	Amt
Sys. BP = 80–125													
Dias. BP = 50–75	88,812	426,153.1	$69,414,617	2,003.1	$215,854,360	1,504	$155,346,804	75.1	71.9	78.3	72.0	62.9	82.1
Dias. BP = 76–80	52,200	251,277.0	43,567,760	1,326.0	161,749,486	1,042	106,249,174	78.6	74.6	82.7	65.7	56.3	76.2
Dias. BP = 81–85	16,267	78,470.5	13,865,518	407.7	48,958,160	332	60,507,160	81.4	74.2	89.2	123.6	95.0	157.1
Dias. BP = 86–90	5,879	28,403.0	4,703,603	144.6	16,716,951	106	13,929,911	73.3	62.0	86.1	83.3	55.8	117.4
Dias. BP = 91–112	755	3,404.7	498,887	15.5	1,609,625	18	789,654	116.0	75.1	171.8	49.1	11.2	122.4
Sys. BP = 126–30													
Dias. BP = 50–75	10,021	49,329.0	6,194,582	353.0	26,846,556	307	31,636,952	87.0	79.0	95.6	117.8	85.8	159.1
Dias. BP = 76–80	18,951	93,656.1	13,760,929	687.2	69,528,536	596	58,279,256	86.7	81.0	92.8	83.8	66.3	104.6
Dias. BP = 81–85	10,918	54,558.4	8,523,811	372.2	43,943,732	334	53,628,160	89.7	81.8	98.2	122.0	91.1	159.8
Dias. BP = 86–90	7,105	34,181.2	5,150,849	193.6	20,697,147	194	25,952,067	100.2	88.7	112.8	125.4	87.3	173.9
Dias. BP = 91–112	1,233	5,609.0	685,606	26.2	2,704,838	23	2,041,798	87.8	60.1	124.3	75.5	32.5	144.8
Sys. BP = 131–35													
Dias. BP = 50–75	3,314	16,782.1	1,688,330	168.0	8,859,526	137	7,785,311	81.5	70.5	93.9	87.9	58.3	125.7
Dias. BP = 76–80	6,753	35,514.8	4,060,256	294.9	21,261,605	308	33,393,381	104.5	94.9	114.8	157.1	113.3	212.9
Dias. BP = 81–85	8,220	42,366.4	5,909,680	356.5	34,234,538	318	26,127,395	89.2	81.2	97.9	76.3	56.5	103.0
Dias. BP = 86–90	5,445	27,448.5	4,085,270	197.0	25,526,474	160	52,595,863	81.2	71.0	92.5	206.0	134.6	300.6
Dias. BP = 91–112	2,114	9,591.6	1,275,057	49.7	4,945,102	50	6,019,588	100.6	78.4	127.2	121.7	57.8	223.6
Sys. BP = 136–40													
Dias. BP = 50–75	2,559	13,719.1	1,399,554	144.6	13,285,580	136	11,935,504	94.1	81.2	108.4	89.8	44.9	159.8
Dias. BP = 76–80	6,754	35,072.0	3,834,318	357.5	25,510,615	378	23,682,454	105.7	97.0	115.1	92.8	71.2	117.8
Dias. BP = 81–85	6,653	34,580.4	4,419,694	329.8	28,392,388	305	28,820,908	92.5	84.0	101.6	101.5	75.0	134.0
Dias. BP = 86–90	10,349	52,528.8	6,762,645	459.0	39,299,692	443	30,277,775	96.5	89.1	104.4	77.0	60.4	100.2
Dias. BP = 91–112	4,316	20,155.1	2,237,012	118.6	12,347,871	97	7,158,373	81.8	68.6	96.8	58.0	34.5	88.6
Sys. BP = 141–45													
Dias. BP = 50–75	432	2,117.5	187,838	25.5	1,692,911	31	1,121,560	121.7	88.2	164.1	66.3	26.6	118.0
Dias. BP = 76–80	1,119	6,179.4	788,590	75.6	4,786,422	85	4,014,667	112.5	93.2	134.6	83.9	41.8	155.3
Dias. BP = 81–85	1,761	10,253.7	1,416,570	128.5	11,709,250	123	5,630,596	95.7	82.0	111.1	48.1	29.8	77.0
Dias. BP = 86–90	3,240	17,302.2	1,894,078	174.9	14,885,268	190	10,585,628	108.6	96.0	122.5	71.1	46.6	104.1
Dias. BP = 91–112	4,126	19,265.2	1,786,596	134.1	8,334,929	133	8,572,106	99.2	85.5	114.5	102.8	69.5	151.0
Sys. BP = 146–230													
Dias. BP = 50–75	996	5,087.9	417,512	75.4	4,008,693	89	3,260,849	118.0	98.3	140.7	81.3	48.2	125.0
Dias. BP = 76–80	1,796	9,296.9	927,209	125.4	6,491,827	153	8,142,234	122.0	106.3	139.4	125.4	80.5	183.2
Dias. BP = 81–85	2,280	12,584.0	1,124,445	177.3	9,469,785	187	7,892,546	105.5	93.2	119.1	83.3	58.1	114.8
Dias. BP = 86–90	4,911	24,875.1	2,242,764	286.0	19,729,476	319	23,625,359	111.5	101.5	122.3	119.7	85.1	164.6
Dias. BP = 91–112	10,654	45,271.6	4,177,244	401.6	28,035,387	549	48,231,577	136.7	127.3	146.7	172.0	126.4	249.3

APPENDIX C

2003 SWISS RE BLOOD PRESSURE STUDY
CAUSE OF DEATH SUMMARY

		Exposed		Expected		Actual		A/E (%)	90 C.I.		A/E (%)	90 C.I.	
Variable Group	Policies Contributing	Policy Years	(1,000s)	Deaths	Amt	Deaths	Claims	Number	Number	Number	Amt	Amt	Amt
Circulatory total	299,933	1,465,033.9	$217,000,824	3,332.7	$284,006,494	3,410	$295,160,140	102.3	99.5	105.2	103.9	93.5	115.4
Sys. BP = 80–125	163,913	787,708.2	132,050,383	1,285.7	129,110,790	987	88,773,258	76.8	72.8	80.9	68.8	58.1	80.9
Sys. BP = 126–30	48,228	237,333.6	34,315,777	569.9	50,471,989	582	68,655,661	102.1	95.2	109.3	136.0	105.5	172.4
Sys. BP = 131–35	25,846	131,703.4	17,018,594	380.4	29,943,255	397	43,184,378	104.5	96.0	113.5	144.2	105.2	193.9
Sys. BP = 136–40	30,631	156,055.4	18,653,224	509.4	38,934,017	582	46,457,580	114.3	106.7	122.4	119.3	91.2	154.7
Sys. BP = 141–45	10,678	55,118.0	6,073,671	196.3	13,315,671	246	12,492,816	125.5	112.7	139.4	93.8	63.1	136.4
Sys. BP = 146–230	20,637	97,115.4	8,889,174	391.1	22,230,773	614	35,596,447	157.1	146.8	167.9	160.1	118.7	216.4
Dias. BP = 50–75	106,134	513,188.6	79,302,432	934.4	78,511,257	749	59,135,855	80.1	75.4	85.1	75.3	60.7	92.6
Dias. BP = 76–80	87,573	430,996.1	66,939,063	995.6	88,461,226	974	87,583,947	97.8	92.7	103.1	99.0	81.6	119.0
Dias. BP = 81–85	46,099	232,813.3	35,259,718	627.7	55,482,412	640	56,700,644	102.0	95.5	108.9	102.2	81.2	127.1
Dias. BP = 86–90	36,929	184,738.7	24,839,209	515.1	43,342,189	663	61,755,439	128.7	120.6	137.2	142.5	110.7	181.9
Dias. BP = 91–112	23,198	103,297.1	10,660,402	260.0	18,209,410	384	29,984,255	147.7	135.6	160.7	164.7	113.7	233.6
Neoplasm total	299,933	1,465,033.9	217,000,824	3,139.9	320,112,376	2,800	263,509,226	89.2	86.4	92.0	82.3	74.3	91.2
Sys. BP = 80–125	163,913	787,708.2	132,050,383	1,285.3	149,908,976	1,045	101,409,104	81.3	77.3	85.6	67.6	57.8	78.8
Sys. BP = 126–30	48,228	237,333.6	34,315,777	530.2	56,411,648	487	60,418,004	91.8	85.1	98.9	107.1	83.2	136.1
Sys. BP = 131–35	25,846	131,703.4	17,018,594	345.0	33,015,335	310	38,829,129	89.8	81.6	98.6	117.6	86.4	158.3
Sys. BP = 136–40	30,631	156,055.4	18,653,224	457.4	41,046,226	434	30,051,770	94.8	87.4	102.6	73.2	56.8	93.8
Sys. BP = 141–45	10,678	55,118.0	6,073,671	174.9	15,021,804	174	10,930,234	99.5	87.4	112.7	72.8	48.2	108.1
Sys. BP = 146–230	20,637	97,115.4	8,889,174	347.0	24,708,387	351	21,870,985	101.1	92.4	110.4	88.5	65.6	120.5
Dias. BP = 50–75	106,134	513,188.6	79,302,432	899.5	92,414,595	741	68,402,236	82.3	77.4	87.5	74.0	60.6	89.9
Dias. BP = 76–80	87,573	430,996.1	66,939,063	934.2	98,601,941	888	71,216,003	95.1	89.9	100.5	72.2	59.9	86.7
Dias. BP = 81–85	46,099	232,813.3	35,259,718	577.8	61,353,364	518	69,118,027	89.7	83.3	96.4	112.7	89.5	140.4
Dias. BP = 86–90	36,929	184,738.7	24,839,209	479.8	47,553,474	407	37,315,918	84.9	78.1	92.1	78.5	61.5	99.4
Dias. BP = 91–112	23,198	103,297.1	10,660,402	248.6	20,189,002	246	17,457,041	99.0	88.9	110.0	86.5	61.0	121.3

Appendix C (continued)

2003 Swiss Re Blood Pressure Study
Cause of Death Summary

Variable Group	Policies Contributing	Exposed: Policy Years	Exposed: (1,000s)	Expected: Deaths	Expected: Amt	Actual: Deaths	Actual: Claims	A/E (%): Number	90 C.I.: Number	90 C.I.: Number	A/E (%): Amt	90 C.I.: Amt	90 C.I.: Amt
Violent death total	299,933	1,465,033.9	$217,000,824	988.7	$155,612,211	818	$195,099,968	82.7	78.0	87.6	125.4	107.3	146.1
Sys. BP = 80–125	163,913	787,708.2	132,050,383	482.5	86,983,596	409	102,541,491	84.7	77.9	91.9	117.9	94.5	145.6
Sys. BP = 126–30	48,228	237,333.6	34,315,777	170.1	26,659,167	134	27,059,240	78.8	67.9	90.9	101.5	70.4	141.0
Sys. BP = 131–35	25,846	131,703.4	17,018,594	98.7	13,964,112	81	30,521,946	81.7	67.4	98.3	218.6	136.0	333.3
Sys. BP = 136–40	30,631	156,055.4	18,653,224	119.6	15,561,060	94	15,799,346	78.5	65.7	93.1	101.5	65.8	155.0
Sys. BP = 141–45	10,678	55,118.0	6,073,671	42.7	5,028,008	27	2,712,841	63.1	44.6	87.0	54.0	26.9	98.5
Sys. BP = 146–230	20,637	97,115.4	8,889,174	75.1	7,416,267	74	16,465,104	98.2	80.3	119.2	222.0	131.8	359.8
Dias. BP = 50–75	106,134	513,188.6	79,302,432	309.7	50,265,885	258	50,165,015	83.2	74.9	92.2	99.8	74.9	131.3
Dias. BP = 76–80	87,573	430,996.1	66,939,063	296.6	48,966,071	243	48,599,991	81.9	73.5	91.0	99.3	75.0	128.3
Dias. BP = 81–85	46,099	232,813.3	35,259,718	168.1	27,030,753	134	38,130,318	79.7	68.8	92.0	141.1	98.3	195.3
Dias. BP = 86–90	36,929	184,738.7	24,839,209	137.7	20,294,481	108	46,578,694	78.6	66.6	92.2	229.5	152.6	339.0
Dias. BP = 91–112	23,198	103,297.1	10,660,402	76.6	9,055,021	75	11,625,949	97.9	80.1	118.6	128.4	77.3	202.8
Other CODs total	299,933	1,465,033.9	217,000,824	2,147.8	171,685,651	1,619	103,465,278	75.4	72.3	78.5	60.3	52.7	68.8
Sys. BP = 80–125	163,913	787,708.2	132,050,383	843.4	78,885,222	561	44,098,852	66.5	61.9	71.3	55.9	45.3	68.2
Sys. BP = 126–30	48,228	237,333.6	34,315,777	362.0	30,178,005	251	15,405,327	69.5	62.4	77.1	51.0	36.7	69.1
Sys. BP = 131–35	25,846	131,703.4	17,018,594	242.0	17,904,544	185	13,386,085	76.6	67.6	86.5	74.8	50.2	108.6
Sys. BP = 136–40	30,631	156,055.4	18,653,224	323.2	23,294,842	249	9,566,318	77.1	69.3	85.6	41.1	29.3	56.9
Sys. BP = 141–45	10,678	55,118.0	6,073,671	124.8	8,043,297	115	3,788,665	92.0	78.4	107.4	47.1	28.7	74.4
Sys. BP = 146–230	20,637	97,115.4	8,889,174	252.4	13,379,741	258	17,220,030	102.2	92.0	113.3	128.7	89.8	183.8
Dias. BP = 50–75	106,134	513,188.6	79,302,432	626.0	49,355,891	457	33,383,874	73.0	67.5	78.8	67.6	51.9	86.8
Dias. BP = 76–80	87,573	430,996.1	66,939,063	640.3	53,299,254	457	26,361,225	71.4	66.1	77.2	49.5	38.6	62.3
Dias. BP = 81–85	46,099	232,813.3	35,259,718	398.4	32,841,325	306	18,657,776	76.9	69.8	84.5	56.8	42.5	75.2
Dias. BP = 86–90	36,929	184,738.7	24,839,209	322.5	25,664,863	234	11,316,553	72.5	64.9	80.8	44.1	32.1	59.5
Dias. BP = 91–112	23,198	103,297.1	10,660,402	160.6	10,524,319	165	13,745,850	102.7	89.9	116.8	130.6	82.5	200.1

Appendix D

2003 Swiss Re Blood Pressure Study
BP 120/80 or Better—Univariate Summary

		Exposed		Expected		Actual		A/E (%)	90 C.I.		A/E (%)	90 C.I.	
Variable Group	Policies Contributing	Policy Years	(1,000s)	Deaths	Amt	Deaths	Claims	Number	Number	Number	Amt	Amt	Amt
Total	118,799	568,408.9	$96,067,893	2,697.4	$306,004,850	2,050	$220,527,187	76.0	73.3	78.8	72.1	64.3	80.6
Gender/smoke = F NS	17,630	91,770.6	16,417,043	283.0	27,968,930	190	22,792,915	67.1	59.4	75.7	81.5	55.9	116.2
Gender/smoke = F SM	5,064	23,299.5	2,407,988	169.3	8,267,024	133	5,245,891	78.6	67.7	90.7	63.5	36.8	100.1
Gender/smoke = F UN	11,298	60,974.0	2,204,091	263.1	5,450,845	210	1,486,580	79.8	71.0	89.5	27.3	17.7	41.5
Gender/smoke = M NS	42,160	198,447.9	53,335,735	781.8	157,297,001	584	106,380,248	74.7	69.7	80.0	67.6	56.6	80.0
Gender/smoke = M SM	13,903	55,714.2	8,970,025	456.6	50,683,587	342	30,912,991	74.9	68.4	81.9	61.0	45.0	81.0
Gender/smoke = M UN	28,744	138,202.7	12,733,010	743.7	56,337,464	591	53,708,562	79.5	74.2	85.0	95.3	78.5	114.8
Age = 14–29	21,183	84,955.3	9,274,295	75.0	6,760,510	87	16,031,222	116.1	96.4	138.7	237.1	125.6	441.1
Age = 30–39	41,708	185,785.9	32,905,541	302.9	44,888,584	257	37,973,483	84.9	76.4	94.1	84.6	63.3	112.4
Age = 40–49	33,937	168,975.9	33,263,651	654.0	93,280,112	532	66,395,771	81.3	75.6	87.4	71.2	57.3	87.9
Age = 50–59	16,888	95,854.3	15,933,121	925.9	95,917,352	697	65,632,506	75.3	70.7	80.1	68.4	56.2	82.5
Age = 60–69	4,537	29,430.2	4,161,584	615.4	47,611,817	387	27,240,972	62.9	57.7	68.4	57.2	44.6	71.8
Age = 70–99	546	3,407.3	529,700	124.2	17,546,474	90	7,253,234	72.4	60.4	86.3	41.3	20.7	66.3
Issue year = 1975–79	49,122	237,270.9	13,545,415	1,199.8	56,851,663	940	44,231,163	78.3	74.2	82.7	77.8	66.1	90.9
Issue year = 1980–84	39,716	168,658.1	30,516,969	1,025.3	132,287,719	811	99,083,635	79.1	74.6	83.8	74.9	61.9	89.8
Issue year = 1985–89	11,323	66,018.9	18,823,219	292.5	61,104,451	197	38,751,033	67.3	59.7	75.8	63.4	46.6	83.4
Issue year = 1990 & up	18,638	96,461.0	33,182,290	179.8	55,761,017	102	38,461,356	56.7	47.8	66.9	69.0	51.6	90.3
Duration = 1–2	117,408	190,016.9	36,456,022	288.1	53,089,529	272	52,982,299	94.4	85.2	104.3	99.8	72.3	134.3
Duration = 3–5	75,344	177,255.1	32,610,521	480.9	81,125,199	452	67,156,815	94.0	86.9	101.6	82.8	64.8	103.9
Duration = 6–10	42,963	131,585.2	21,162,907	651.5	88,122,336	533	43,403,303	81.8	76.1	87.9	49.3	39.8	60.3
Duration = 11–15	12,513	41,877.2	4,278,867	488.9	44,260,316	367	30,183,957	75.1	68.8	81.8	68.2	51.2	88.6
Duration = 16–20	5,450	19,398.1	1,296,003	479.8	29,398,775	283	24,178,299	59.0	53.4	65.1	82.2	62.4	105.5
Duration = 21 & up	2,306	8,276.4	263,574	308.2	10,008,695	143	2,622,514	46.4	40.2	53.3	26.2	20.0	34.2
Family history = adverse	8,727	40,147.7	7,951,016	188.4	24,740,594	165	20,101,721	87.6	76.7	99.6	81.2	55.9	112.7
Family history = neutral	61,901	290,118.4	36,448,830	1,255.5	103,207,292	977	74,779,115	77.8	73.8	82.0	72.5	61.4	85.0
Family history = favorable	48,171	238,142.8	51,668,047	1,253.5	178,056,963	908	125,646,350	72.4	68.5	76.5	70.6	59.8	82.8

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