Persistence of Individual Mortality Risk Differentials Utilizing A Modified Online Predictive Market

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Executive Summary

The Society of Actuaries Futurism Section and Social Technologies collaborated on a project to investigate the persistence of individual life insurance risk mortality differentials by utilizing an approach inspired by online predictive markets. Preferred risk programs have become an essential part of individual life insurance programs in the term life and universal life markets. The best preferred risk classes have experienced significantly better mortality than higher risk classes in early policy durations. However, mortality experience that demonstrates how long mortality discounts at the best risk classes will persist does not exist due to the relative recent introduction of preferred risk classes.

Online prediction markets were used as the inspiration for a process where participants assessed the expected persistence of risk discounts/premiums for six specified risk criteria. A baseline set of risk criteria were established, against which additional risk premium (residual standard risk) and risk discount (preferred risk) conditions were specified and applied to hypothetical age cohorts of 35-year-olds and 60-year-olds. Participants assessed the extent to which the risk discounts/premiums were present at time of policy issue in 2006, and how much of the discount/premium would remain in 2021 and 2036.

For both 35-year-olds and 60-year-olds, the risk discounts/premiums were judged to persist in large part over the 30-year period. Specifically, 74 percent of the risk discount for issue age 35 and 68 percent of the risk discount for issue age 60 was judged to persist for 30 years. For issue age 60, this indicates that the participants judged over two-thirds of the risk discount persisting to age 90. Regarding risk premiums, a higher proportion of the risk premium was judged to persist over the 30-year period. Ninety-six percent of the risk premium for issue age 35 and 86 percent of the risk premium for issue age 60 was judged to persist for 30 years.

Regarding the impact of specific criteria, smoking status and blood pressure were found to have the greatest and longest lasting impact on the overall risk discount/risk premium at each of the durations. However, the order of introduction of the specific criteria may have had a material impact on the relative impact of different criteria.

Collection of participant explanations for assessments revealed a wide diversity of opinions among participants regarding the magnitude of risk assessments and their duration over time.

Introduction

The Society of Actuaries Futurism Section and Social Technologies collaborated on a project to investigate the persistence of individual life insurance risk mortality differentials by utilizing an approach inspired by online predictive markets. Preferred risk programs have become an essential part of individual life insurance programs in the term life and universal life markets. The best preferred risk classes have experienced significantly better mortality than higher risk classes in early policy durations. However, mortality experience that demonstrates how long mortality discounts at the best risk classes will persist does not exist due to the relative recent introduction of preferred risk classes.

In an attempt to gain better insight into the persistence of preferred risk mortality differentials, this project used a modified version of an online "predictive market" process to investigate both the degree and extent to which both preferred risks and risk premiums are expected to persist over 15-year and 30-year time horizons. Sixty life industry experts from primarily the actuarial, underwriting and medical insurance fields participated in the study.

Prediction markets create an artificial market for speculative bets, for the purpose of

making more accurate collective predictions about the future. Prediction markets allow participants with expert or relevant knowledge to aggregate and compare their information in a neutral environment with many opportunities for participants to revise or reassess their judgments. Through "trading" of these artificial contracts, a consensus opinion on outcomes is revealed from the actions of the participants.

An example of a conventional prediction market is the Web site Intrade Prediction Markets (formerly Tradesports.com), which offers real-money prediction markets on a wide range of topics. For example, there is an existing market regarding Democratic Party presidential candidates for the 2008 election. As of July 2007, trading shows Hillary Clinton a front-runner with a 45.4 percent chance of being the nominee, with Barack Obama the nearest competition with a 38.9 percent chance of being the nominee.

Conventional predictive markets typically have a short-term outcome that can be definitively determined true or false. However, this project involved assessments of the future persistence of risk discounts and risk premiums—questions for which there will be no definitive answers for many years. To address this challenge, the study designers modified the conventional approach to prediction markets and instead developed a hybrid approach that preserved the market metaphor and anonymous participation, while posing open-ended questions about the future expected duration of risk discounts/premiums.

Methodology

Given the wide range of risk characteristics, time horizons and demographic characteristics from which to choose, the list of potential variables was streamlined down into a more manageable list. The prospective time horizon was divided into three units: the present

(2006), 15 years in the future (2021) and 30 years in the future (2036). The assumed policy age of issue was divided into two generalized age categories: 35 and 60. Finally, a set of relevant risk characteristics and risk criteria was identified (see Table 1).

Table 1: Risk Characteristics and Risk Criteria

Smoking Status	Never smoked
	No cigarettes in last year (baseline)
	Pipe smoking allowed
Total Cholesterol /HDL	Cholesterol/HDL: 4.5
	Cholesterol/HDL: 5.5 (baseline)
	Cholesterol/HDL: 7.0
Blood Pressure	125/80
	140/90 (baseline)
	150/95
Family History of Cancer	No cancer diagnosis of parents or siblings before age 65.
	No cancer deaths of parents or siblings before age 60. (baseline)
	No cancer deaths of parents before age 50.
Driving Record	< 1 moving violation in 2 years and no DUI ever.
	< 2 moving violations in 3 years and no DUI in 10 years. (baseline)
	< 3 moving violations in 3 years and no DUI in 5 years.
Build (5'10")	180 pounds
	200 pounds (baseline)
	215 pounds

The multiple combinations of the variables and the risk criteria were combined together into a form similar to those used by a predictive market. Much as a prediction market will represent a proposition bet in terms of a trading contract, this project transformed the multiple permutations of the variables into a series of hypothetical propositions, which the participants evaluated and "priced" in six different rounds.

The multiple rounds of surveys were conducted using readily accessible online survey tools (i.e., Surveyconsole.com), and participants were able to participate online at any time during the specified two-week evaluation rounds. During each round of voting, open-ended

questions collected comments from participants on the rationale behind their adjustment to their scores in each round.

Discussion

Prices in prediction markets often change in response to new information or events that are perceived to change the relative probabilities of a proposition occurring in the future. However, factors that impact risk differentials have a slow rate of change. In order to simulate news-induced gyrations in "prices," the process took the approach of incrementally revealing new risk criteria in successive evaluation rounds. At the beginning of the evaluation process, participants were informed of baseline risk characteristics for a cohort of fictitious individual life pools. The life pool cohorts were presumed to be all male, in order to keep the number of variables down to a manageable level.

At the initiation of the process, participants were told to assume all of the risk propositions to have identical values for characteristics such as build, blood pressure, cholesterol, etc. This is the initial baseline against which the mortality divergences were to be evaluated throughout successive rounds of voting. This baseline of risk criteria was set to a baseline score of 100, for scoring purposes.

Participants adjusted their scores for each new risk characteristic against baseline scores that started at 100 in the initial round, with the baseline changing as a result of the scoring from each prior round. For example, a score of 87 would reflect an assessment that the cohort should have a - 13 percent discount compared to the baseline. A score of 121 would reflect an assessment that the cohort should have a premium of 21 percent above the baseline. Simply stated, lower numbers/prices represented better mortality than the baseline, while higher numbers

represented worse mortality than the baseline. After each round of the survey, the average and median results of the scoring for each risk proposition were calculated, and the resulting score/price for each was displayed next to each evaluation field for participants, so they could use the scores to better calibrate their scoring for the next round—or that these averages may have influenced the responses to each successive round.

In each of the six rounds, one of the actual risk criteria was revealed for participants to evaluate and score. The staggered introduction of explicit risk criteria provided a reason for participants to change their assessment, similar to the way in which exogenous news events can change event probability perceptions in a conventional prediction market. Staggered introduction of risk criteria also provided an opportunity to separate out the assessed risk premium/discount for each criterion, by extracting the net changes for each score from round-to-round.

Three cohorts were defined: a risk discount cohort (representative of a preferred risk), a baseline cohort and a risk premium (representative of a residual standard risk). The staggering took the form of a sequencing of risk criteria through each successive round that differed between the cohorts (see Table 2).

Table 2: Introduction Sequence of Risk Criteria

Rounds	Risk Discount Cohort Criteria	Risk Premium Cohort Criteria
Round 1	Blood Pressure	Smoking Status
Round 2	Total Cholesterol/HDL	Build
Round 3	Driving Record	Blood Pressure
Round 4	Family History of Cancer	Total Cholesterol /HDL
Round 5	Smoking Status	Driving Record
Round 6	Build	Family History of Cancer

One possible impact of the sequential introduction of criteria is that early introductions of criteria with higher potential impact could have a conditioning effect on the scoring on successive

rounds. High scores for criteria in the first few rounds has the potential to constrain scoring for later risk criteria, since initial scores can "calibrate" the relative scoring of successive rounds. Another potential impact is that scoring in later rounds could be affected by the aggregate risk scores introduced each round. These aggregate scores could cause participants to alter their scoring upward or downward to better align their scores with the total risk discount or premium applicable to the cohort. The staggering of the introduction of criteria between the cohorts was intended to blunt these impacts.

This sequencing enabled us to look at the assessment of individual criteria. Adjustments from one round to the next were assumed to be due to the new criterion that was introduced in that round; however, the full decision could have also been partially based on the new average that was provided.

The project had 60 participants drawn from a variety of relevant backgrounds. Information about the professional profiles of the participants was collected, and just over half of the participants were professional actuaries and/or worked for life insurers (see Table 3).

Table 3: Professional Affiliations of Participants

Profession	# Participants	**Employers**	# Participants
Actuary	32	Life Insurer	31
Medical Director	12	Reinsurer	22
Underwriter	11	Consulting Firm	4
Other	5	Other	3
Total	60	Total	60

Results

Risk premiums/discounts for specific criteria were calculated by taking the difference in scores for each variable in each round. Changes in scores reflected participant assessments of the percentage change in the risk premium/discount, for each specific risk characteristic. All scoring by project participants were performed in comparison to a baseline set of risk characteristics, as shown below in Table 4.

Table 4: Baseline Risk Criteria

General Criteria	***Specific Criteria for Baseline***
Smoking Status	No cigarettes in last year
Total Cholesterol / HDL	Cholesterol/HDL: 5.5
Blood Pressure	140/90
Family History of Cancer	No cancer deaths of parents or siblings before age 60
Driving Record	< 2 moving violations in 3 years and no DUI in 10 years.
Build	200 pounds

Scores for each specific risk characteristic were derived using the averaged scores of each round. During each round, for each general risk characteristic (i.e., blood pressure), specific risk criteria were revealed for the risk premium cohort, as well as for a risk discount cohort. During each round, participants gave separate evaluations of the risk for various ages of issue (35 and 60), and across multiple timeframes (2006, 2021, 2036).

For example, in the first round of evaluation for the risk discount cohort the revealed risk discount criteria were related to blood pressure. At the start of the round, the baseline risk level for the cohort was assumed to be at the baseline level of 100, reflecting a baseline blood pressure of 140/90. During the round, the blood pressure for the risk discount cohort was revealed to be 125/80. Participants answered by specifying how the risk discount should be adjusted in six hypothetical cases:

- Age of issue 35 and the preferred risk differential that exists in 2006

- Age of issue 35 and the preferred risk differential that exists in 2021 (15 years after issue)
- Age of issue 35and the preferred risk differential that exists in 2036 (30 years after issue)
- Age of issue 60 and the preferred risk differential that exists in 2006
- Age of issue 60 and the preferred risk differential that exists in 2021 (15 years after issue)
- Age of issue 60 and the preferred risk differential that exists in 2036 (30 years after issue)

Thus a participant score of 87 would reflect an assessment that the risk pool should have a 13 percent discount compared to the baseline of 100. For each round, each of the participant answers were averaged, and the new baseline score was provided as a reference for scoring the next revealed risk criteria. This process was repeated through six rounds of scoring, through which the six different risk criteria were introduced.

Participant rationales for their answers were also collected for each round. Participant comments tended to fall into clusters, which have been gathered together for each risk characteristic in the Appendix. However, some participant comments will be selectively used in the following discussion to illustrate the potential rationales that explain the risk discount and risk premium data.

This methodology for assessing the duration of risk discounts strongly emphasizes the average risk scores derived for each risk criterion. Although participants scored each round independently, each round used the average risk scores of the prior rounds as a baseline upon which to build the risk assessments for the next set of criteria. It is the baseline of the average participant round scoring that carries over from round to round, not the individual scores of a given participant.

This allows for a degree of partial participation among the participants. If a participant scored an early round and later ceased participation, his/her scores in the early rounds were embedded in the average scoring of the early rounds, and his/her non-participation in later rounds would have only a minimal impact on the average scores of the later rounds. This also

provided flexibility for participants that missed scoring for a round, since the absence of any given individual would have minimal impact on the average scores for that round.

Persistence of Risk Discount/Risk Premium

The mortality differentials due for the two cohorts at issue, 15 years after issue and 30 years after issue were judged by the participants for issue ages 35 and 60. Implicitly, the participants were also judging the proportion of the risk discount/risk premium that would persist after issue over both a 15-year and 30-year horizon. The following table shows the risk discount/risk premium for both issue age 35 and 60 in 2006, 2021 and 2036 and the implicit persistence of the risk discount and risk premium:

Table 5: Risk Discount for 2006, 2021 and 2036 and Implied Persistence of Discount after Issue

General Criteria	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Discount	*-28.4%*	*-25.4%*	*-21.0%*	*-27.7%*	*-23.4%*	*-18.9%*
Implied Persistence of Discount	*100.0%*	*89.4%*	*73.9%*	*100.0%*	*84.5%*	*68.2%*

Note: Implied persistence of discount represents the proportion of the initial preferred risk discount that persists after issue (i.e., 2006). For example, 89.4 percent of the initial preferred risk discount (-25.4%/-28.4%) persists in 2021 for initial age 35.

Table 6: Risk Premium for 2006, 2021 and 2036 and Implied Persistence of Discount after Issue

General Criteria	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Premium	*51.0%*	*49.3%*	*48.9%*	*43.6%*	*40.8%*	*37.6%*
Implied Persistence of Premium	*100.0%*	*96.7%*	*95.9%*	*100.0%*	*93.6%*	*86.2%*

Over two-thirds of the risk discount has been judged to persist for issue age 60; that is, by attained age 90, two-thirds of the benefits of preferred risk underwriting have been judged to still be in effect. For issue age 35, almost three-quarters of the risk discount has been judged to

persist. A higher proportion of risk premium has been judged to persist for 30 years: over 95 percent of the risk premium persists for 30 years for issue age 35 and over; 85 percent of the risk premium has been judged to persist for issue age 60. We observe that less of the risk discount is assumed to persist as compared to the risk premium.

Risk Discount Data

For the hypothetical cohort with preferred risk characteristics over the baseline, the net effects of all six criteria lead to a risk discount of 28.4 percent for 35-year-olds, and 27.7 percent for 60-year-olds as shown in Table 7 below. Looking forward to 2036, participants judged that a portion of this risk discount would erode, with the degree of risk discount falling to 21.0 percent for 35-year-olds, and 18.9 percent for 60-year-olds, as both groups aged over the 30-year timeframe. Blood pressure and smoking status were judged as making the largest contribution to the risk discount. However, in both age 35 and age 60 cohorts, the magnitude of these effects wore off with time.

Table 7: Derived Risk Discount Assessments (average scores)

General Criteria	Specific Criteria	Initial Age = 35			Initial Age = 60		
		2006	2021	2036	2006	2021	2036
Blood Pressure	125/80	-9.5%	-8.5%	-7.3%	-13.9%	-11.5%	-8.6%
Total Cholesterol / HDL	Cholesterol/HDL: 4.5	-4.9%	-3.5%	-2.2%	-2.7%	-2.0%	-1.5%
Driving History	< 1 moving violation in 2 years and no DUI ever.	-3.6%	-2.6%	-2.4%	-1.0%	-1.8%	0.0%
Family History (Cancer)	No cancer diagnosis of parents or siblings before age 65.	-0.9%	-1.8%	-0.1%	-0.6%	-0.1%	-0.3%
Smoking Status	Never Smoked	-8.1%	-8.0%	-8.7%	-8.2%	-6.3%	-5.9%
Build (for Male, 5' 10")	180 pounds	-1.3%	-1.0%	-0.3%	-1.3%	-1.6%	-2.6%
Total Discount		***-28.4%***	***-25.4%***	***-21.0%***	***-27.7%***	***-23.4%***	***-18.9%***

Risk Discount Changes for the Age 35 Cohort

Chart 1: Duration of Risk Discounts, Issue Age = 35

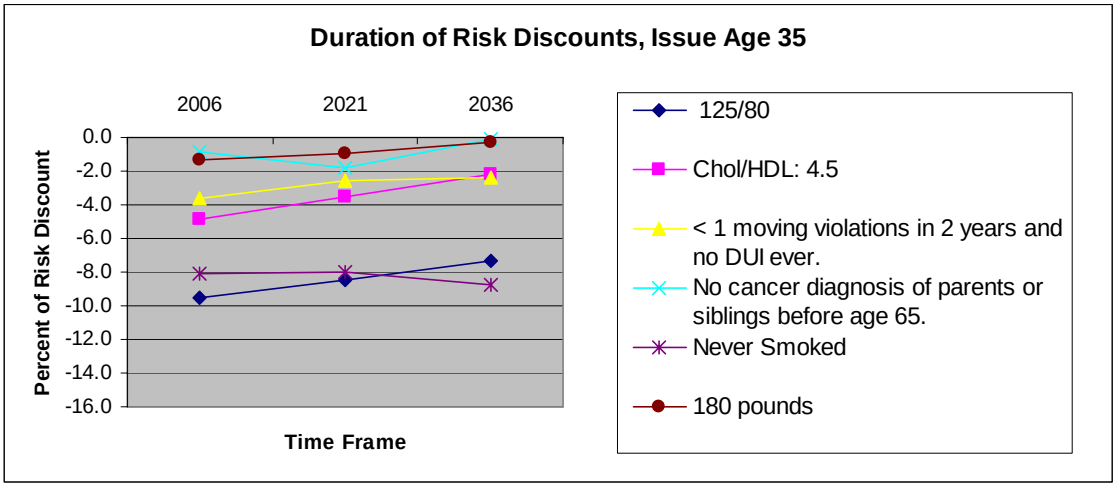


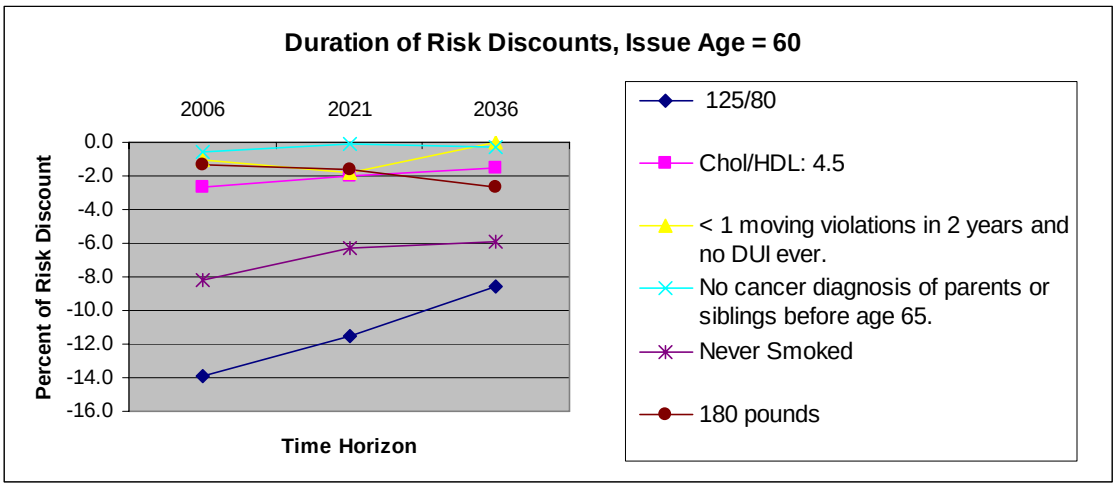
Chart 1 visually illustrates how the risk discounts for each of the six specific risk criteria were judged to change over time for the age 35 cohort. While the risk discounts for specific risk criteria were judged to gradually decrease over time, smoking status proved to be an exception—the risk discount increased as the time horizon approached 2036. In part, this divergence could be explained by participants assuming that the beneficial effect of never smoking will increase over time. Several participants commented that *never smoking* is more positive than *not smoking in the past year*, since: "If they did not smoke in last year, there remains more risk that the person will start or go back to smoking than if never smoked."

The risk discounts for build and family history of cancer both dwindled to near zero after 30 years. For build, commenters perceived that younger cohorts have more time to shift towards adoption of unhealthy lifestyles: "A younger individual has more time for an adverse change in lifestyle." For family history, the results reflect commenter sentiment that the "impact of genetic history wears off as an individual gets older."

Risk discounts for cholesterol/HDL and blood pressure both declined in linear fashion over time, reflecting commenter sentiments that the beneficial impacts of both of these characteristics tend to wear off with age. The risk discount for driving history declined with age, with the rate of declines slowing as the cohort got older.

Risk Discount Changes for the Age 60 Cohort

Chart 2: Duration of Risk Discounts, Issue Age = 60



For issue age 60, while the risk discounts for specific risk criteria were judged to gradually decrease over time, build proved to be an exception—the risk discount increased as the time horizon approached 2036. However, the increase in risk discount over time was relatively marginal, increasing from 1.3 percent in 2006 to 2.6 percent by 2036. This may reflect the sentiment of one commenter, who assumed "persistent improvement over time, with greater improvement in older [age] cohort."

The blood pressure risk factor made the greatest contribution to the risk discount, with an initial discount of 13.9 percent in 2006 declining to 8.6 percent by 2036. Despite the magnitude

of the decline, the blood pressure criterion made the highest contribution to the risk discount across all time horizons. Although it should be noted that blood pressure was the first criterion introduced for this cohort, the initial size of the risk discount reflects participant sentiment of "lifestyle/habits considered more reliable for older ages," and the decline of the discount reflecting the belief that the impact of beneficial blood pressure criterion will "go toward median/average over time."

The risk discounts for driving history and family history of cancer both dwindled to near zero after 30 years. For driving history, the overall decline may have to do with decreasing relevance for the criterion with age: "Driving habits do not wear off, but have very limited predictive value at older ages." For family history, the results reflect commenter sentiment that "for the 60-year-old, I expect the impact on mortality to be less important."

Risk discounts for cholesterol/HDL declined in linear fashion over time, with smaller discounts when compared to the age 35 cohort. Interestingly, a majority of comments stated that the cholesterol/HDL criterion would have "More impact on older persons," or "greater significance over time," yet the overall scoring for that risk criterion didn't reflect these sentiments.

Risk Premium Data

For the hypothetical cohort with more negative risk characteristics than the baseline, the net effect of all six criteria led to a risk premium of 51.0 percent for 35-year-olds, and 43.6 percent for 60-year-olds. Looking forward to 2036, participants judged that only a marginal portion of the risk premium would erode for the 35-year-old cohort, with the degree of risk discount falling to 48.9 percent over the hypothetical 30-year time frame. The risk premium

declines somewhat more for the 60-year-old cohort, falling to 37.6 percent by 2036. As was the case for the risk discounts, the risk premiums for blood pressure and smoking status were judged as making the largest contribution to increased mortality risk. However, unlike the risk discount cohort, blood pressure was not the first criterion introduced; it was the fourth criterion introduced.

Table 8: Derived Risk Premium Assessments (average scores)

General Criteria	Specific Criteria	Initial Age = 35			Initial Age = 60		
		2006	2021	2036	2006	2021	2036
Blood Pressure	150/95	16.4%	17.5%	17.3%	13.0%	14.9%	19.2%
Total Cholesterol / HDL	Cholesterol/ HDL: 7.0	5.5%	3.4%	0.9%	2.1%	-0.2%	-1.3%
Driving History	Driving < 3 moving violations in 3 years and no DUI in 5 years	2.1%	1.3%	1.8%	3.6%	2.3%	-0.8%
Family History (Cancer)	No cancer deaths of parents before age 50.	7.6%	7.8%	8.2%	4.9%	5.2%	3.7%
Smoking Status	Pipe smoking allowed	18.1%	20.3%	22.6%	19.5%	19.7%	17.9%
Build (for Male, 5' 10")	215 pounds	1.3%	-1.0%	-1.9%	0.5%	-1.1%	-1.1%
Total Premium		***51.0%***	***49.3%***	***48.9%***	***43.6%***	***40.8%***	***37.6%***

Risk Premium Changes for the Age 35 Cohort

Chart 3: Duration of Risk Premiums, Issue Age = 35

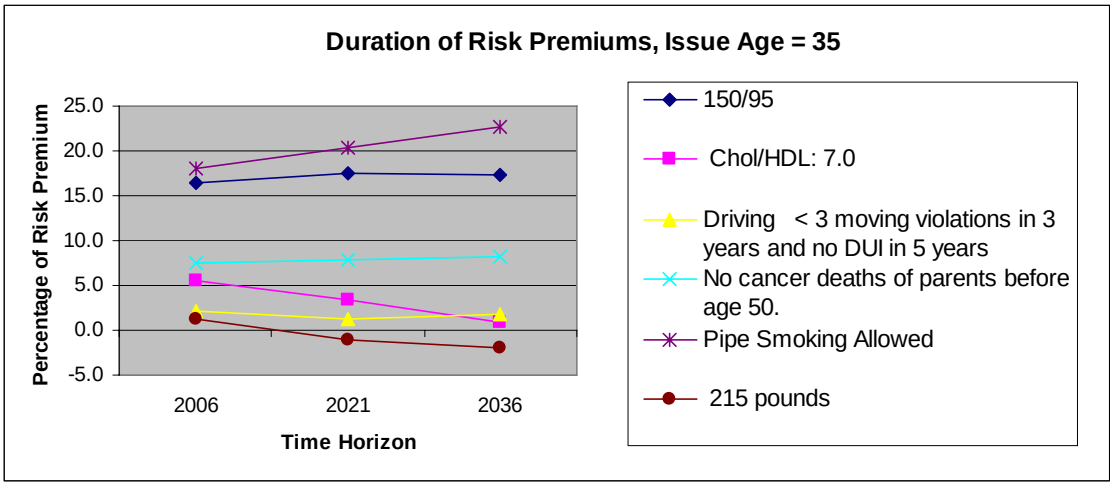


Chart 3 visually illustrates how the risk premiums for each of the six specific risk criteria were judged to change over time for the age 35 cohort. For the age 35 cohort, the risk premium for both smoking status and blood pressure increased over time. The risk premium for smoking status rose from 18.1 percent in 2006 to 22.6 percent by 2036. For these younger cohorts, the participant sentiment that "smoking is an accelerating impairment" was a popular response, closely followed by the assertion that "pipe smoking could cover up other smoking and/or indicate past smoking."

The blood pressure risk premium only increased slightly, rising from 16.4 percent in 2006 to 17.3 percent by 2036. The relative stability of the blood pressure risk premium matches participant sentiment that a blood pressure of "150/95 is stage 2 hypertension and carries clear extra mortality." Family history of cancer was also generally perceived as a stable risk over the time horizon, increasing from only 7.6 percent in 2006 to 8.2 percent in 2036. Although commentary on the risk criterion was mixed, some participants expressed that the risk criterion

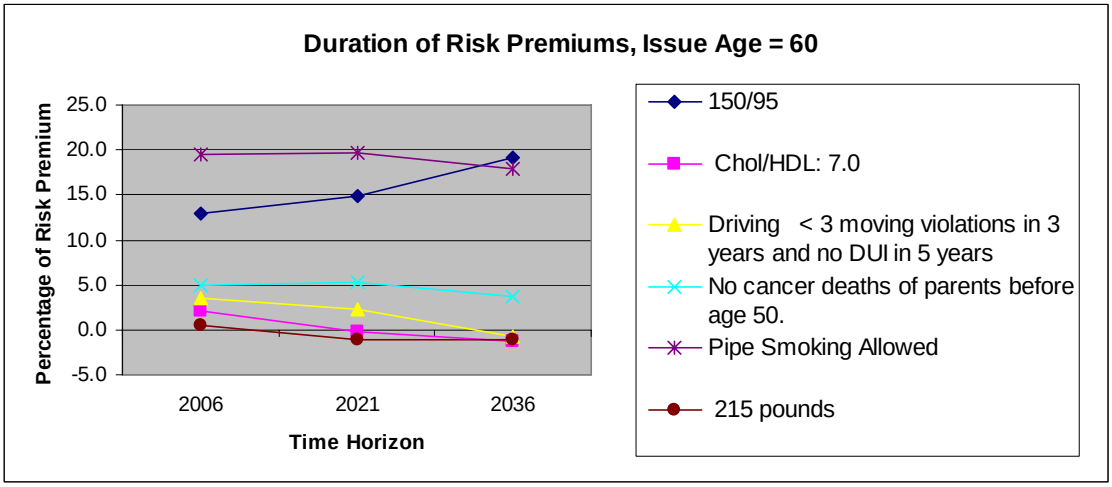
for family history of cancer was “significant for younger people, opening the door for some lousy family history.”

The risk criterion for cholesterol/HDL decreased substantially for this cohort, dropping from 5.5 percent in 2006 to 0.9 percent in 2036. Participants gave the largest decrease at younger ages, matching sentiment that “HDL ratio has its biggest impact on early ages and durations.” Driving history was assessed at having a minimal risk premium that fluctuated slightly around 2 percent and reflected the participant sentiment that the risk criterion implied a “slight decrease at younger attained ages.”

Build was assessed as having a minimal impact on the risk premium, with it declining from 1.3 percent in 2006 to -1.9 percent in 2036. The decline to a negative number implies that over time the build risk criterion evolves from being a small risk premium to becoming a small risk discount. This notion was not mentioned in participant comments, so the evolution of this risk premium to a marginal risk discount is likely an artifact of participants doing their assessments using a baseline set to 100, somewhat obscuring the score that would imply a zeroing out of the risk premiums.

Risk Premium Changes for the Age 60 Cohort

Chart 4: Duration of Risk Premiums, Issue Age = 60



As seen in Chart 4, smoking status had the highest initial risk premium for the age 60 cohort, beginning at 19.5 percent in 2006 and rising to 19.7 percent by 2021, and then falling to 17.9 percent by 2036. The decrease in the risk premium in later years reflects the comments of several participants that over time a survivor effect begins to appear, and that "by age 90, it appears that cohort has beat the odds so only a small mortality increase."

The blood pressure risk premium was the second largest for the cohort, gradually growing from 13.0 percent in 2006 to 19.2 percent by 2036. By 2036, it edged out smoking status as having the highest premium. Participants had few comments on this risk factor, generally emphasizing the "higher risk of heart disease." The lack of commentary combined with the strong evaluation scores may reflect a generally accepted consensus of opinion among the participants that the condition implies accelerating mortality with age.

The risk premium for family history of cancer was 4.9 percent in 2006, rose slightly to 5.1 percent in 2021, and then declined to 3.7 percent by 2036. With such a small variation, it is

difficult to meaningfully determine whether participants generally perceived a growing risk premium during the first 15 years of the time horizon. One commenter noted that "strict family history should improve mortality but as a real world issue [it is] very difficult to adhere to such strict guidelines in the marketplace." Other commenters noted that "for someone already 60, the impact on mortality is still important," a rationale in line with the gradual reduction of the risk premium over time.

Finally, cholesterol/HDL and build risk criteria had initial risk premiums of 2.1 percent and 0.5 percent in 2006, and both rapidly declined to zero by 2021, indicating that the participants assessed both criteria as having minimal impact on mortality.

Risk Discount/Premium Institutional Affiliation Analysis

Project participants came from several types of employers and professional affiliations. To determine whether these professional affiliations had discernable effects of risk assessments, information on these affiliations were collected as part of the survey process. In the tables that follow, the average risk assessments for each professional affiliation are presented, as well as the implied persistence of risk discount/premium for each professional affiliation. Respondents were asked to state both their professional affiliation (actuary, underwriter, medical director) as well as their type of employer (life insurer, reinsurer). In the following tables, both categories are presented together to simplify comparisons. It should be noted that each group did not have equal numbers of participants in the process, so the resulting tabulations should not be viewed as conclusive representations of risk assessment tendencies among the life casualty professions.

Table 9: Risk Discount by Professional Affiliation for Issue Age 35/60 in 2006, 2021, 2036

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Discount Score	*-28.4%*	*-25.4%*	*-21.0%*	*-27.7%*	*-23.4%*	*-18.9%*
Actuary	-29.7%	-26.2%	-22.4%	-29.4%	-25.1%	-21.1%
Underwriter	-27.3%	-25.0%	-21.5%	-27.0%	-22.8%	-18.3%
Medical Director	-27.0%	-22.2%	-17.0%	-22.8%	-18.2%	-14.2%
Life Insurer	-28.2%	-25.1%	-20.6%	-28.0%	-23.5%	-18.9%
Reinsurer	-28.5%	-25.2%	-20.1%	-27.4%	-22.6%	-17.8%

Table 10: Implied Persistence of Risk Discounts by Professional Affiliation for Issue Age 35/60 in 2006, 2021, 2036

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Discount Persistence	*100.0%*	*89.4%*	*73.9%*	*100.0%*	*84.5%*	*68.2%*
Actuary	100.0%	88.2%	75.5%	100.0%	85.4%	71.8%
Underwriter	100.0%	91.7%	78.9%	100.0%	84.3%	67.6%
Medical Director	100.0%	82.2%	63.0%	100.0%	79.8%	62.3%
Life Insurer	100.0%	88.8%	72.9%	100.0%	83.8%	67.6%
Reinsurer	100.0%	88.3%	70.4%	100.0%	82.6%	65.1%

The persistence of risk discount was relatively consistent between actuaries and underwriters and between those affiliated with life insurers and reinsurers. However, we note that medical directors assumed that a materially lower proportion of the risk discount persisted than either actuaries or underwriters.

Table 11: Risk Premiums by Professional Affiliation for Issue Age 35/60 in 2006, 2021, 2036

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Premium Score	*51.0%*	*49.3%*	*48.9%*	*43.6%*	*40.8%*	*37.6%*
Actuary	53.5%	49.2%	45.7%	50.3%	45.5%	41.8%
Underwriter	41.9%	42.9%	43.1%	29.9%	30.4%	30.9%
Medical Director	41.6%	39.0%	37.6%	33.8%	31.8%	24.4%
Life Insurer	52.8%	50.6%	50.5%	45.4%	41.4%	38.4%
Reinsurer	44.5%	42.4%	40.3%	40.4%	37.5%	31.3%

Table 12: Implied Persistence of Risk Premiums by Professional Affiliation for Issue Age 35/60 in 2006, 2021, 2036

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Total Risk Premium Persistence	*100.0%*	*96.7%*	*95.9%*	*100.0%*	*93.6%*	*86.2%*
Actuary	100.0%	92.0%	85.3%	100.0%	90.5%	83.2%
Underwriter	100.0%	102.4%	103.0%	100.0%	101.7%	103.3%
Medical Director	100.0%	93.8%	90.4%	100.0%	94.1%	72.2%
Life Insurer	100.0%	95.9%	95.7%	100.0%	91.3%	84.6%
Reinsurer	100.0%	95.2%	90.4%	100.0%	92.9%	77.4%

One notable result is that the risk premiums for underwriters appeared to grow over time, rather than decay. In part this is due to all but one of the underwriters assigning a risk premium that did not decline over time (i.e., nearly 100 percent persistence), and a single underwriter assigning a risk premium that rose over time.

Additional data regarding risk differentials and institutional affiliation for the six specific criteria used in the study can be found in Section 1 of the Appendix.

Conclusions

This project was designed to explore how prediction markets could be used to gain better insights into how risk premiums and risk discounts for specific risk criteria can be expected to persist in the future. The process as implemented used a prediction market metaphor that gave participants a novel form in which to address the persistence of risk discounts and risk premiums over time.

The primary finding was a differential in the overall persistence of risk discounts and risk premiums over time. For both 35-year-olds and 60-year-olds, the risk discount/premiums were judged to persist in large part over the 30-year period. Specifically, 74 percent of the risk discount for issue age 35 and 68 percent of the risk discount for issue age 60 was judged to persist for 30 years. For issue age 60, this indicates that the participants judged over two-thirds of the risk discount persists to age 90. Regarding risk premiums, a higher proportion of the risk premium was judged to persist over the 30-year period. Ninety-six percent of the risk premium for issue age 35 and 86 percent of the risk premium for issue age 60 were judged to persist for 30 years.

A secondary finding was that blood pressure and smoking status emerged as the two risk criteria that maintained the largest risk discounts/premiums over the expected 30-year time horizon, for both younger and older cohorts.

The comments for participants were not shared with the participants during the process, so each participant was only affected by the net scoring changes—not the opinions of colleagues. As a result, their mental models for risk assessment were less affected by feedback from other participants during the process. Because of this, the participant comments preserved a wide

variety of opinions, and in some cases even contradictory viewpoints on why risk assessments are expected to change over time. The wider range of participant comments for each risk criterion is presented in the Appendix, and it demonstrates that there is a wide variety of individual mental models for how risk discounts and premiums change over time.

Another intriguing finding was the general trends in risk assessments among the various professions and employers. Although this data is more evocative than conclusive, it does seem to indicate that institutional affiliations can have tangible effects on how risks are assessed and expected to change over time.

Further exploration of this methodology for determining risk assessments could generate more comprehensive results by implementing several modifications:

1) Risk change justifications could be collected for each criterion ahead of time, and then used to consistently force participants to agree with standardized justifications for why they are changing their risk assessments.
2) More age information about risk discounts could be generated by using fewer criteria, but more variety in the age cohorts or time horizons.
3) More conclusive data about how institutional affiliations shape the assessment of risk assessments could be generated by actively recruiting more equal numbers of participants from each risk assessment background.
4) Introduction of all-female cohorts could provide additional information on gender-specific differences in the expected duration of risk discounts and risk premiums.

Appendix

The appendix has two sections, each with a different type of supplementary data:

1. **Section 1:** Supplementary data on risk assessment differentials for each of the 6 specific risk criteria between subgroups of professional affiliation among the participants.
2. **Section 2**: A condensed version of participant comments that were made during each round.

Appendix Section 1: Supplementary Professional Affiliation Information

Section 1 of this Appendix provides breakout tables detailing the specific risk premiums and risk discounts for each of the six specific risk criteria.

Given the small sample sizes for each professional category, the data should be taken as indicative, and not definitive. The following table indicates the number of participants from each profession per round, excluding participants from other professional categories, and surveys that were blank, incomplete, or invalid.

Table 13: Number of participants per round, by professional affiliation

	Smoking Status	*Blood Pressure*	*Total Cholesterol / HDL*	*Family History (Cancer)*	*Build (for Male, 5' 10")*	*Driving History*
Actuary	16	21	17	16	15	17
Underwriter	7	8	7	7	8	6
Medical Director	4	6	5	6	7	5
Life Insurer	16	17	20	17	18	16
Reinsurer	9	13	8	8	9	9

The rest of the Section 1 of this Appendix presents the overall group risk assessments for a specific criteria, followed by the average assessments for both professions (actuary, underwriter, medical director) and employers (life insurers, reinsurers).

Table 14: Professional Affiliation Information for Smoking Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	*-8.1*	*-8.0*	*-8.7*	*-8.2*	*-6.3*	*-5.9*
Actuary	-9.6	-10.1	-8.6	-7.4	-8.6	-6.3
Underwriter	-6.7	-5.2	-8.7	-5.7	-10.3	-7.3
Medical Director	-5.3	-4.6	-3.8	-2.6	-4.8	-3.1
Life Insurer	-8.3	-9.9	-8.0	-7.3	-8.9	-6.2
Reinsurer	-6.2	-5.4	-6.6	-5.4	-7.4	-6.1

Table 15: Professional Affiliation Information for Smoking Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	*18.1*	*20.3*	*22.6*	*19.5*	*19.7*	*17.9*
Actuary	20.8	22.2	22.6	21.6	24.0	19.3
Underwriter	8.7	9.4	11.9	11.6	15.7	15.3
Medical Director	19.7	18.2	23.0	20.2	24.3	16.7
Life Insurer	16.6	17.2	17.1	8.0	12.7	8.4
Reinsurer	17.2	18.2	19.4	25.9	28.2	29.0

Table 16: Professional Affiliation Information for Blood Pressure Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	-9.5	-8.5	-7.3	-13.9	-11.5	-8.6
Actuary	-9.0	-9.0	-8.5	-13.5	-11.4	-9.0
Underwriter	-12.6	-9.6	-7.0	-17.1	-14.3	-10.1
Medical Director	-10.3	-7.3	-5.8	-15.0	-11.3	-9.0
Life Insurer	-9.0	-7.2	-5.4	-14.8	-11.5	-8.4
Reinsurer	-10.4	-8.3	-7.1	-12.5	-9.8	-7.3

Table 17: Professional Affiliation Information for Blood Pressure Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	16.4	17.5	17.3	13.0	14.9	19.2
Actuary	9.0	7.4	4.8	8.6	8.2	7.2
Underwriter	6.9	11.5	14.3	6.5	10.2	14.7
Medical Director	17.6	19.1	14.3	9.0	11.0	23.2
Life Insurer	11.2	11.5	12.7	7.3	8.0	14.3
Reinsurer	14.9	17.1	14.4	13.3	14.6	15.4

Table 18: Professional Affiliation Information for Total Cholesterol/HDL Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	-4.9	-3.5	-2.2	-2.7	-2.0	-1.5
Actuary	-6.9	-5.7	-4.4	-4.1	-3.4	-3.3
Underwriter	-3.5	-2.0	0.0	-3.2	-2.9	-1.1
Medical Director	-2.2	-1.0	-0.1	3.5	4.1	3.4
Life Insurer	-4.9	-3.5	-1.6	-2.8	-1.7	-0.5
Reinsurer	-5.8	-4.3	-3.2	-3.3	-2.2	-1.7

Table 19: Professional Affiliation Information for Total Cholesterol/HDL Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	5.5	3.4	0.9	2.1	-0.2	-1.3
Actuary	6.8	4.3	-0.6	6.0	2.3	-1.2
Underwriter	1.3	2.8	0.6	-7.7	-7.1	-8.6
Medical Director	-5.8	-9.2	-13.0	-9.2	-12.3	-14.3
Life Insurer	5.7	3.6	3.5	0.1	-2.0	-0.6
Reinsurer	2.6	0.8	-4.6	3.4	0.7	-4.9

Table 20: Professional Affiliation Information for Family History of Cancer Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	-0.9	-1.8	-0.1	-0.6	-0.1	-0.3
Actuary	-2.1	-2.4	-0.3	-0.4	0.0	0.2
Underwriter	-0.8	-0.8	0.5	-0.4	-0.4	-1.3
Medical Director	-2.3	-1.0	1.3	-0.4	1.3	0.1
Life Insurer	-0.2	-0.7	0.4	0.8	1.2	0.9
Reinsurer	-2.8	-2.4	-0.6	-0.9	-0.7	-2.3

Table 21: Professional Affiliation Information for Family History of Cancer Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	7.6	7.8	8.2	4.9	5.2	3.7
Actuary	10.1	7.7	5.0	11.6	9.9	7.9
Underwriter	-1.5	1.4	2.4	-8.8	-5.2	-3.0
Medical Director	-1.8	-2.5	-3.1	-4.9	-3.8	-9.5
Life Insurer	9.4	9.1	9.8	6.7	5.8	4.5
Reinsurer	1.1	0.9	-0.4	1.7	1.9	-2.7

Table 22: Professional Affiliation Information for Build Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	-1.3	-1.0	-0.3	-1.3	-1.6	-2.6
Actuary	-2.7	-1.8	-0.7	-3.0	-3.4	-4.8
Underwriter	-0.3	-0.6	0.2	-0.6	-1.1	-2.0
Medical Director	0.0	2.2	4.7	3.6	3.5	2.1
Life Insurer	-1.2	-0.7	1.1	-1.6	-1.8	-2.6
Reinsurer	-1.5	-0.8	1.6	-1.0	-0.9	-1.5

Table 23: Professional Affiliation Information for Build Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	1.3	-1.0	-1.9	0.5	-1.1	-1.1
Actuary	0.4	-2.9	-4.1	1.2	0.5	1.2
Underwriter	-5.1	-4.9	-5.2	-7.9	-7.1	-3.9
Medical Director	-5.7	-8.3	-10.2	-11.5	-12.7	-12.9
Life Insurer	-1.9	-3.5	-3.4	-2.2	-3.2	-2.5
Reinsurer	2.1	-2.0	-5.3	0.8	-1.1	-2.5

Table 24: Professional Affiliation Information for Driving Record Risk Discount

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	-3.6	-2.6	-2.4	-1.0	-1.8	0.0
Actuary	-3.9	-3.7	-3.5	-2.6	-2.9	-1.9
Underwriter	1.7	1.2	1.0	4.3	2.2	0.9
Medical Director	-4.0	-3.8	-3.3	-0.6	-2.3	5.5
Life Insurer	-2.7	-2.0	-1.2	-1.1	-1.3	-0.3
Reinsurer	-1.7	-2.4	-2.1	-0.6	-2.2	1.3

Table 25: Professional Affiliation Information for Driving Record Risk Premium

Professional Affiliation	Initial Age = 35			Initial Age = 60		
	2006	2021	2036	2006	2021	2036
Original Total Score	2.1	1.3	1.8	3.6	2.3	-0.8
Actuary	2.2	0.5	-0.2	4.7	3.9	1.0
Underwriter	-2.2	-0.5	0.7	-2.1	-1.0	-1.3
Medical Director	-4.9	-7.2	-9.7	-4.3	-6.9	-10.1
Life Insurer	5.2	3.3	4.2	6.3	4.4	-0.6
Reinsurer	-1.9	-3.3	-4.2	0.9	-0.3	-2.6

Appendix Section 2: Participant Comments

Comments tended to fall into clusters of similar rationales, which have been collected together into these tables, with the rationale for each cluster indicated using a representative comment.

Risk Discount Cohort, Blood Pressure Criteria Comments

Representative Comment	Frequency
Lower blood pressure is associated with favorable mortality.	6
Lower blood pressure criteria should have a greater effect on the age 60 cohort. Expect smaller impact on age 35 cohort.	5
Favorable systolic/diastolic blood pressure. More relative and persistent benefit at younger age.	4
Lifestyle/habits considered more reliable for older ages.	3
Improving blood pressure cause the cardiovascular system to be under less stress, decreasing the chances of other heart ailments.	2
Blood pressure seems high for 35 yr old, low for 60 yr old. Both go toward median/average over time.	2
Other	4
Total	26

Risk Discount Cohort, Cholesterol/HDL Criteria Comments

Representative Comment	Frequency
More impact on older persons. I can see the value wearing off more rapidly on younger people.	5
Cholesterol/HDL carries greater significance over time and progressive ages should reflect this.	4
An improved Cholesterol/HDL ratio will improve the mortality of the cohort.	4
Not giving much weight to cholesterol score, but it does matter a little, and the lower cholesterol helps.	2
Total	15

Risk Discount Cohort, Driving History Criteria Comments

Representative Comment	Frequency
Slightly better driving record and no DUIs indicates a slight improvement in mortality expectations. However, not a significant improvement.	5
Driving habits do not wear off, but have very limited predictive value at older ages.	3
Driving fatalities a significant source of early extra mortality so some improvement justified.	2
Minimal credit, since this is not that great a deviation from what we would expect; credit wears off on age 60 since applicant is less likely to be driving with passage of time.	2
No DUI ever seems to indicate a more reliable and likely-to-be-continued practice, and more so at a later age.	2
Other	2
Total	16

Risk Discount Cohort, Family History of Cancer Criteria Comments

Representative Comment	Frequency
Impact of genetic history wears off as individual gets older.	4
Pricing would be a small bit better for the younger lives up until the 60's.	4
Unlike other factors, I believe the family history factor gains in importance as years go by.	1
No credit at age 60 since insured is essentially at the age involved in the family history.	1
No family history of cancer before age 65 is even better than before age 60. But for the 60 years old, I expect the impact on mortality to be less important.	1
Other	4
Total	15

Risk Discount Cohort, Smoking Status Criteria Comments

Representative Comment	Frequency
The 'never smoked' criteria is much more favorable than 'does not smoke'.	4
The impact of no smoking is felt most in younger ages and durations. Overall, never smoking makes anyone a better risk in general.	3
If they did not smoke in last year, there remains more risk that the person will start or go back to smoking than if never smoked. Furthermore, if someone smoked for a few years, their general health will never be as good as someone who never smoked.	3
The impact of never having smoked is more significant for someone who is 60 since they could have been smoking for a much longer period of time.	2
Other	1
Total	13

Risk Discount Cohort, Build Criteria Comments

Representative Comment	Frequency
Younger individual has more time for an adverse change in lifestyle	3
Lower weight favorable but not significantly so	3
No changes; did not feel the weight difference would have a significant impact.	2
Tighter definition with more effect at younger age.	1
Persistent improvement over time, with greater improvement in older cohort.	1
Total	10

Risk Premium Cohort, Blood Pressure Criteria Comments

Representative Comment	Frequency
The combination of adverse factors compounds the risk, making the resulting risk more than the sum of its parts.	2
150/95 is stage 2 hypertension and carries clear extra mortality.	2
Somewhat greater effect of higher blood pressure at younger issue age.	2
Consistent with substandard mortality rather than preferred	1
As people get older it doesn't matter what cohort they started in.	1
Problem likely to get worse.	1
Other	1
Total	10

Risk Premium Cohort, Cholesterol/HDL Criteria Comments

Representative Comment	Frequency
Higher risk of heart disease.	4
Lipid profile exceeds criteria.	2
Closer to substandard than preferred.	1
HDL ratio has its biggest impact on early ages and durations.	1
More impact for age 60 cohort – improving at long durations because of competing causes.	1
Total	9

Risk Premium Cohort, Driving History Criteria Comments

Representative Comment	Frequency
If DUI in the past 5 to 10 years, I am more concerned with a 60 years old (drinking problem). So that is why I would leave an impact for age 60 cohort even if might not be driving anymore at 75 or 90 years old.	3
Little favorable results to be expected from liberalizing criteria.	3
Small credits for tighter DUI criterion for issue age 35, but no effect on 65 year-old.	3
Other	3
Total	12

Risk Premium Cohort, Family History of Cancer Criteria Comments

Representative Comment	Frequency
Slight decrease at younger attained ages for 35 year-old, as a result of the improved family history. Due to the ages involved, this has no impact on the 60 year-old.	2
For someone already 60, the impact on mortality is still important but a little bit less than 35 years old.	2
Significant for younger people - opens door for some lousy family history. But, the overall risk looks reasonable with a modest increase.	2
If criteria followed very strict family history it should improve mortality but as a real world issue very difficult to adhere to such strict guidelines in the marketplace.	2
Age is below positive family history threshold.	1
Negative impacts of genetics, pipe smoking, blood pressure & cholesterol should grade downward - more rapidly for older insured.	1
Other	1
Total	11

Risk Premium Cohort, Smoking Status Criteria Comments

Representative Comment	Frequency
Smoking is an accelerating impairment.	5
Pipe smoking could cover up other smoking and/or indicate past smoking.	4
The impact would grow over time for the 35 year old as more years of smoking would accumulate. For the 60 year old, the differential would increase initially but then eventually tend towards zero.	4
Expect smaller proportion of pipe smokers at age 35. Impact of exposure over longer duration more at age 60.	3
Pipe smoking causes only a little change, if any, in mortality.	3
Significantly higher mortality for pipe smoker population than non-smoking population.	2
Pipe smokers, though no where near as bad as smokers, will have elevated risks compared to non-smokers that would still continue.	2
Other	3
Total	26

Risk Premium Cohort, Build Criteria Comments

Representative Comment	Frequency
Smoking and overweight are bad risk factors that tend to stick around.	6
15 pounds overweight is an additional health risk.	5
A few more pounds will only slightly worsen mortality.	3
Lifestyle is more likely to change for 35 years old, so effect should dilute with time for 35 years old. I don't think the same apply for 60 years old. Generally harder to change lifestyle, lose weight and exercise at 60 and over.	1
No immediate effect on 35 year olds, but increased effect with age. Lower effect on 60 year olds after 30 years because they have lived so long with the impairments.	1
Other	1
Total	17