TrueRisk® Life Population Study

A Study of TrueRisk® Life as a Mortality Predictor in the Contemporary United States Credit Active Population

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RGA

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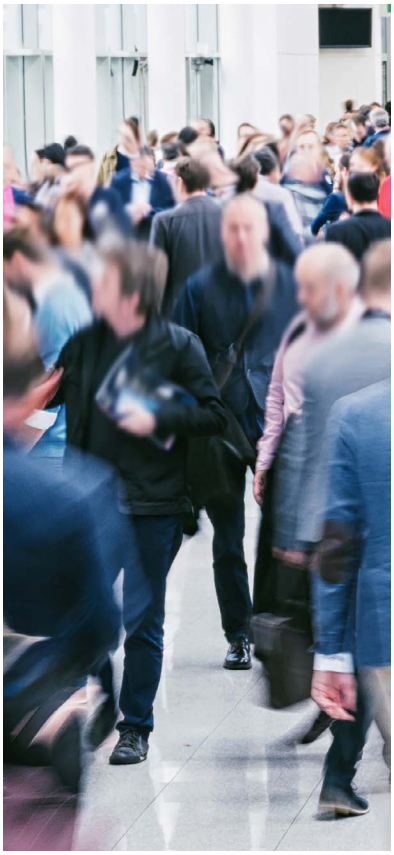
Executive Summary



In 2013, Reinsurance Group of America (RGA) and TransUnion LLC (TransUnion) began to research the protective and predictive nature of credit behavior for the purpose of understanding relevance as it pertained to mortality risk. RGA's goal was to understand the relationship between credit attributes and mortality outcomes. Given credit data's successful implementation in analyzing risk in adjacent markets, like property and casualty insurance, it appeared to be an ideal behavior to explore for the life insurance market.

In 2014, a product version of a credit-based insurance score, TrueRisk® Life, was finalized by TransUnion. As discussed in the 2019 published article (Rushing, Kueker), RGA validated the newly created model by analyzing the risk score's ability to predict mortality in the credit active population. In the decade since, the underwriting tool has proven itself to be a valuable asset to American life and group insurers. While not explicitly covered in this study, TrueRisk® Life has demonstrated, via studies of carrier insured blocks, to enable improved mortality risk segmentation and simplify the underwriting process, removing friction, cost and time to better meet customer expectations.

With the aim of building on the insightful 2019 whitepaper, this paper offers a fresh look at U.S. Population mortality trends. RGA studied TrueRisk® Life's ability to segment mortality risk by leveraging a dataset from TransUnion containing 50 million lives, 6 million deaths, and 500 million scores. The study covers years 1999-2020 – a period made possible by a compilation of death sources, provided by TransUnion.

Armed with this new data, RGA has targeted key research topics including:

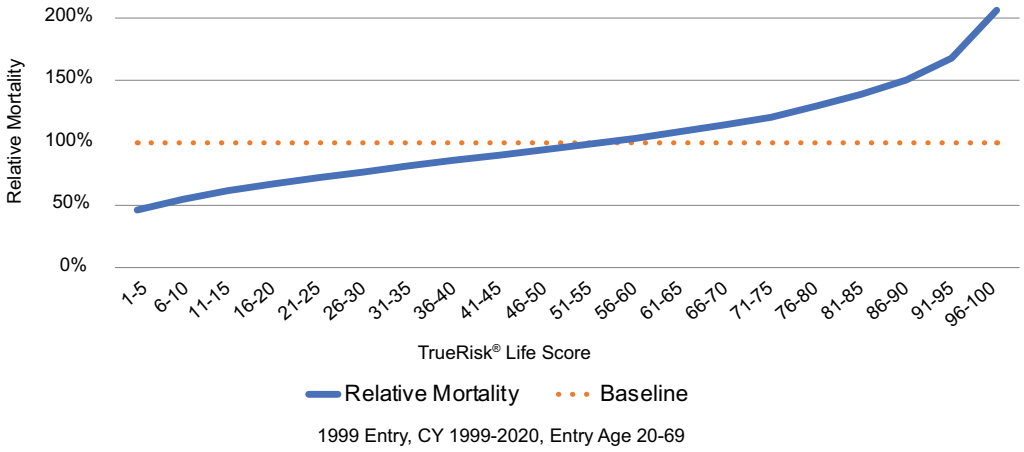
- **TrueRisk® Life as a Long-Term Predictor** This updated population study builds on the previous publication (Rushing, Kueker), following subjects for an extensive 22-year follow-up. TrueRisk® Life achieves 4.48x segmentation between the best and worst risks (1-5 and 96-100, respectively) over the study period (Figure 1). Performance would likely be even stronger if deaths were not disproportionally underreported for people with high TrueRisk® Life scores.
- **Score Performance in Recent Years** TrueRisk® Life continues to demonstrate strong predictive power when applied in more recent years despite a changing external environment (Figure 7).
- **Score Persistence**
  - **Over Time** Distributions of population TrueRisk® Life scores are less uniform in 2009 and 2019 than in 1999, with increasing prevalence in the highest/lowest scores (Figure 2).
  - **In Individuals** Score persistence, the magnitude of score change for an individual year-over-year, depends on the initial risk. People with high or low scores tend to "persist" at their initial risk level, staying "favorable" or "unfavorable" risks for extended periods of time (Figure 13). Age also plays a factor, with the youngest ages being somewhat less persistent than their older counterparts (Figure 12).

- **Persistence and Mortality** Due to responsive score movements, even in rare instances of sizeable score changes, we see a corresponding impact on mortality experience. (Figure 14).

- **Scored People with Limited Credit History** Individuals with a limited credit history typically have very high scores (Figure 16). The mortality segmentation for people with limited files is comparable to that of people with more robust credit history (Figure 17).

- **Overall Take-Away** Over the entire study period, mortality was over 4x higher for the "riskiest" 5% of study entrants compared to the "safest" 5%.

Figure 1: Relative Mortality by TrueRisk® Life Score



- **RGA's Take** RGA has leveraged its extensive industry experience with TrueRisk® Life to identify three key considerations for users and adopters:

1. TrueRisk® Life continues to be a strong predictor of mortality, even over the extended time period in this study.
2. While smaller individual movements will occur, score stability is very strong when considering ranges of scores that may be associated with certain underwriting rules. A large majority of individuals in the highest and lowest score groups remain within those groups when scored 5 years later.
3. While a shift in population score distributions has occurred since the 1998 cohort in the original study, this shift predates the dozens of studies RGA has completed on insured blocks, whose relevance to carriers' use of TrueRisk® Life is much greater. Consequently, the population shift observed in this study should not necessitate changes for carriers currently using TrueRisk® Life.

Limitations

The information contained in this report is confidential and may not be distributed, disclosed, copied or otherwise furnished to any third party without the prior consent of RGA. Nothing included in this report may be used in any filing with any public body, such as but not limited to the Securities and Exchange Commission (SEC) or state insurance department without prior written consent from RGA.

RGA has relied upon data provided by TransUnion and did not perform independent audits of the data, although RGA did review the data for general reasonableness and consistency. To the extent there are material errors in the data, the results of this report will be impacted. Data used in this analysis pertains to U.S. population data, not the life insurance buying population. Some estimates are included in the data and discussed in the Methodology section of this report. To the extent these estimates are in error, the results of this report will be impacted. RGA, its directors, officers and employees disclaim liability for any loss or damage arising or resulting from any errors or omissions in this analysis and summary of the results or any other information contained herein. The report is to be reviewed and understood as a complete document. The analysis in this report contains information related to mortality and experience studies. Assistance should be sought by an actuary with knowledge of such matters as experience studies. This report should be read in its entirety. RGA shares in the fees collected by TransUnion for TrueRisk® Life.

Population Study

Data

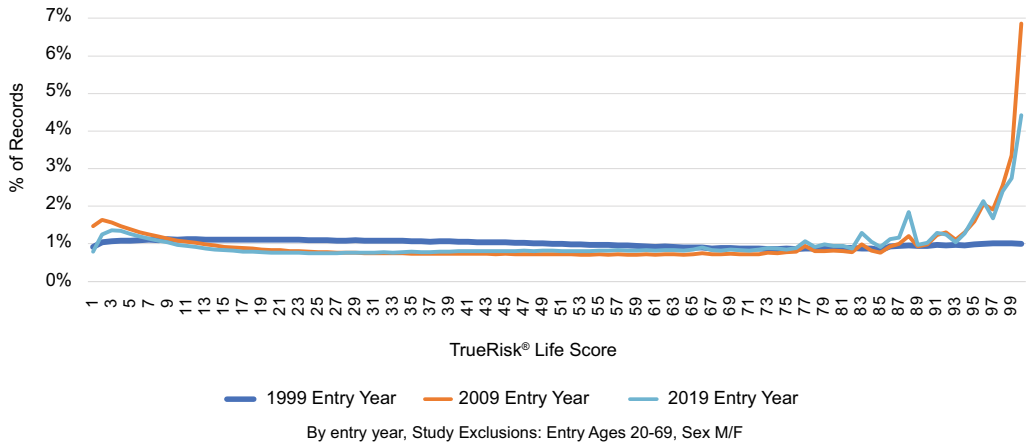
Overview There are three different cohorts of data representing individuals alive at the beginning of 1999, 2009, and 2019. These randomized cohorts are mutually exclusive with each other, so no person should appear more than once across the three different datasets. Each cohort contained information on the person's demographics, date of death, and a TrueRisk® Life score calculated for each year after the original year. Each cohort's data was then converted into an experience study for the analysis. Notably, the 1999 cohort in this study represents the same individuals as in the original population study completed in 2012 (Rushing, Kueker). For each cohort, individuals will enter the study on January 1 using the most recent score captured at the time of entry and will remain in the study until the date of death on record, or until the study ends.

Summary Statistics Cohorts were largely the same in terms of entry age and sex distributions. Distributions of TrueRisk® Life scores differed noticeably from cohort to cohort, with a much higher portion of records receiving scores of "99" or "100" scores in later cohort years (2009, 2019). This observed distribution difference is noticeable in calendar years as early as 2000 and is not driven by entry year sample selection.

Figure 2: Record Counts by Cohort – After Experience Study Exclusions

Cohort Year	Person Count	Exposure Count	Deceased Count
1999	11,614,645	238,247,819	2,027,901
2009	16,597,408	191,755,727	1,497,560
2019	7,973,959	191,755,727	1,497,560

Figure 3: TrueRisk® Life Distributions at Entry by Cohort



Methodology

1. **Define Expected Basis**

   U.S. population mortality was chosen as the expected basis varying by attained age, sex, and calendar year. Available mortality tables were extended by RGA actuaries through the study end date of December 31, 2020.

2. **Account for Missing Deaths**

   - **Background** Prior to Q4 2011, deaths are determined using the Social Security Master Death File (SSMDF), which was a nearly complete and reliable source of deaths. For Q4 2011 and later, deaths are sourced from a variety of different datasets to compensate for the increasingly incomplete SSMDF.
   - **Expected Death Adjustments** The combination of all the death files provided a satisfactory coverage of population mortality to extend the experience study through the end of 2020. To account for the underreporting of deaths across the entire 22-year study, expected mortality rates were adjusted by the rate of which deaths were identified. A combination of public and proprietary data sources was used to develop these adjustments. Because the rate at which deaths were captured depended greatly on the age and year of death, True Positive Rate adjustments were made by age groups and calendar year. This process was intended to create even actual to expected death rates across age groups and calendar years, facilitating year-to-year and age-to-age comparisons of TrueRisk® Life performance.
   - **Example** If it were estimated that 92% of all deaths in 2019 for people aged 50-55 were correctly identified (with the remainder incorrectly surviving), the expected number of deaths would be multiplied by a factor of .92. In general, adjustments were larger for older groups in later calendar years.

     Study Expected Deaths = Expected Deaths Population (Age, Sex, Year) * True Positive Rate (Age, Calendar Year)

   - **Additional Considerations** The limitations of the death data (see Figure 6 and Figure 7) could skew results and impact how TrueRisk® Life performs in this study. This would occur if there was the underreporting of deaths at the highest scores or the introduction of false positive deaths at the lowest scores. There was not attempt to adjust expected basis for these potential scenarios.

3. **Blend Expected Mortality by Sex**
   "Sex" as provided by TransUnion is a probability-based estimate, not a self-reported data point. Initial analysis showed females having higher mortality rates than anticipated using sex distinct tables, with the reverse being true for males. This likely means that a portion of males and females are misclassified. Initial age-sex-year mortality rates indicated that about 7.5% of those coded males are female (and vice versa). Blended male and female mortality rates were created by calculating the weighted average of male and female mortality rates based on the assigned sex using a 92.5%/7.5% weight.

4. **Exclude Records with Unknown Sex**
   Records without predicted sex were removed. These records represented about 6% of the original exposure.

5. **Age Exclusions**
   - **Attained Age and Mortality** The robustness of credit-usage has a direct relationship with the data available for matching to the study's death sources. Credit usage tends to decrease as individuals age and the study results showed that older ages seem to be missing a significant amount of deaths. Therefore, to ensure the study has complete deaths across all included years, the study was limited to:

     1. 1999 Cohort covering a 1999-2020 study period:
        a. Retained Entry Ages: 20-69
     2. 2009 Cohort covering a 2009-2020 study period:
        a. Retained Entry Ages: 20-80
     3. 2019 Cohorts covering a 2019-2020 study period:
        a. Retained Entry Ages: 20-80

   The 2009 and 2019 cohorts retain a greater amount of the older age population deaths compared to the 1999 cohort. We are confident this is true because the observed mortality trends begin to degrade with respect to the population rates beyond these age/calendar year cells. This could be due to credit usage changes in recent years for this subset of the population, making data more available for matching purposes.

Areas of Research

This updated population study was initiated to explore the following research topics:

Extending Study Period

The original population study was completed using a 12-year follow up (1999-2010). This new study covers 1999-2020, facilitating research on TrueRisk® Life as a long-term predictor. The original population mortality study showed that TrueRisk® Life was a strong predictor over 12 years. Therefore, a primary objective for this paper is to understand the performance of TrueRisk® Life in later study years.

Assessing Performance in Recent Years from Other Cohorts

Having additional cohorts in the study will allow for experimentation with more recent "entry dates" and enables the comparison of risk segmentation achieved in recent calendar years to that of the original 1999 cohort. Additionally, the distributions of recent TrueRisk® Life scores can provide insight into current market conditions.

Differentiating Risks in Senior Population

TrueRisk® Life's performance has been shown to be age dependent, with the model achieving less segmentation for the oldest "entry ages." However, our previous understanding of this was limited to the original population study which only included entrants under 70. This updated study allows for the reliable analysis of people aged 70-79 at entry.

Individuals with Limited Credit Data

The data provided for study includes a TransUnion defined field indicating whether an individual has limited credit history (i.e., "thin" credit file), allowing for deeper analysis of TrueRisk® Life scores and corresponding mortality. While having a "thin file" is more common among younger people, the attribute appears across all ages.

TrueRisk® Life Score Persistence over Time

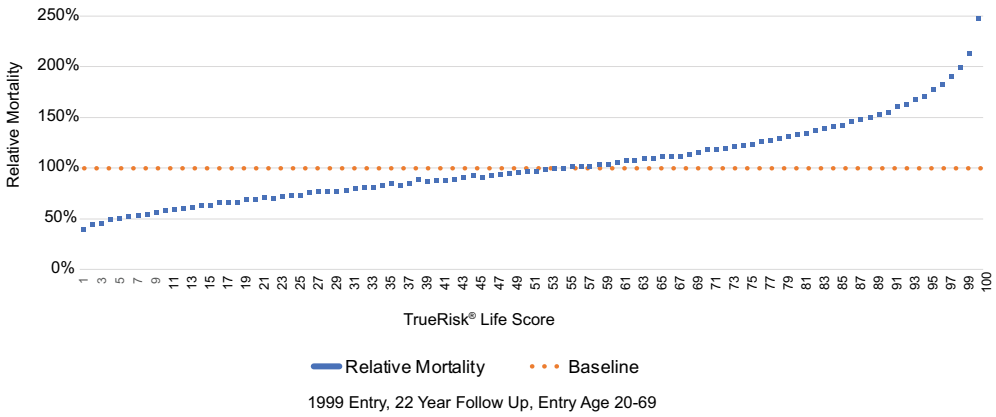
The data includes a yearly TrueRisk® Life score for most records. This allows the year-over-year changes in scores to be understood and the corresponding impact on mortality to be analyzed.

Results

TrueRisk® Life Retains Predictive Power in Extended Study

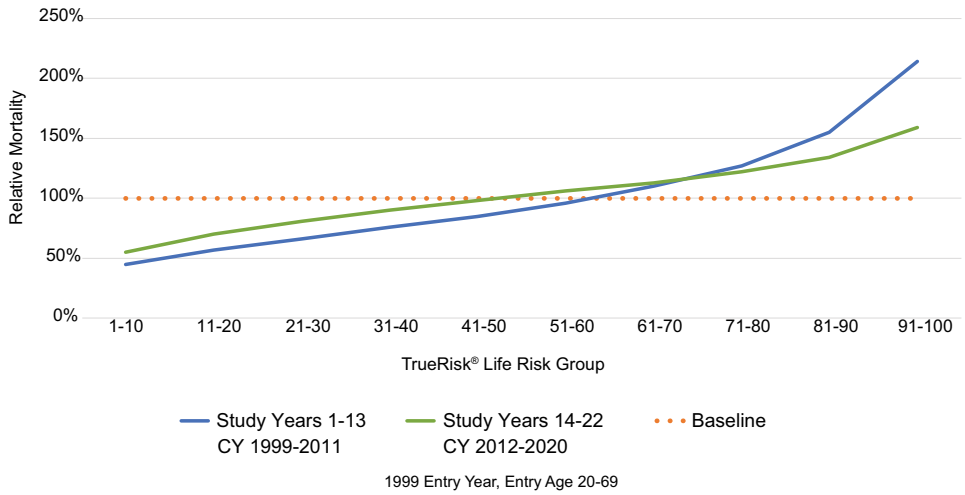
A key motivation for completing an updated U.S. population study was to investigate how TrueRisk® Life performs in later study years. Previous analyses covered shorter periods (1999-2010), with 1999 as the only entry point. This study follows subjects for a longer period (1999-2020) and compares the performance of TrueRisk® Life across three different entry-years (Rushing, Kueker). Such a study set-up has allowed for a more complete assessment of TrueRisk® Life as a long-term predictor and offers insight into the score's value in 2022.

Figure 4: Actual to Expected Deaths by TrueRisk® Life Score



Overall, TrueRisk® Life effectively segments mortality risk over the 22-year study period as illustrated by Figure 4. The attributes used in modeling are seemingly indicative of behavioral characteristics (conscientiousness) correlated with a person's credit history. After adjusting expected deaths for age, gender, and calendar year, TrueRisk® Life is shown to be a strong predictor of long-term mortality risk.

Figure 5: Actual to Expected Deaths by TrueRisk® Life Score and Follow-Up Period



When extending exposure to later study years, TrueRisk® Life retains most of its predictive power. Figure 5 compares risk segmentation in the first 13 study years and the remaining nine years of experience now available for analysis. As expected, some segmentation is lost in later study years. However, TrueRisk® Life is clearly predictive of mortality many years after scoring.

Figure 6: TrueRisk® Life Risk Segmentation by Study Year – Explanations for Falling Segmentation

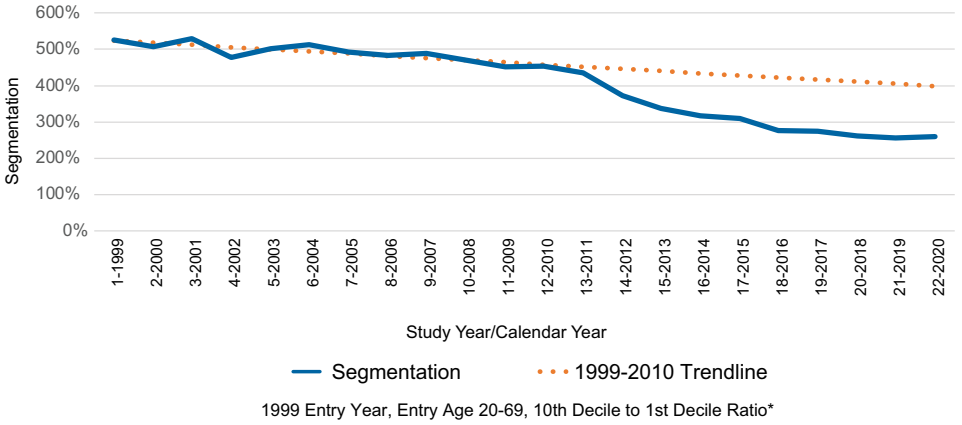


Figure 6 illustrates TrueRisk® Life's ability to distinguish the mortality of individuals with the "worst scores" (91-100) from the "best scores" (1-10) over time. The vertical axis is the ratio of the 91-100 group relative to the mortality of the 1-10 group. Basically, Figure 6 shows TrueRisk® Life's ability to distinguish "the worst of the worst" by study year. Naturally, the risk segmentation is less pronounced in later study years, with risk segmentation decreasing at a greater rate after study year 13. Notably, study years 13/14 coincides with the calendar years 2011/2012 – the years when the study's death source becomes decreasingly dependent on the SSMDF. With that said, it is possible that the mortality (A/E) for the 91-100 group is underreported and/or the presence of false positive deaths is inflating the mortality (A/E) for the 1-10 group.

TrueRisk® Life Performs Comparably in Recent Years

Figure 7: Relative Mortality by TrueRisk® Life and Entry Year – 12 Year Follow Up

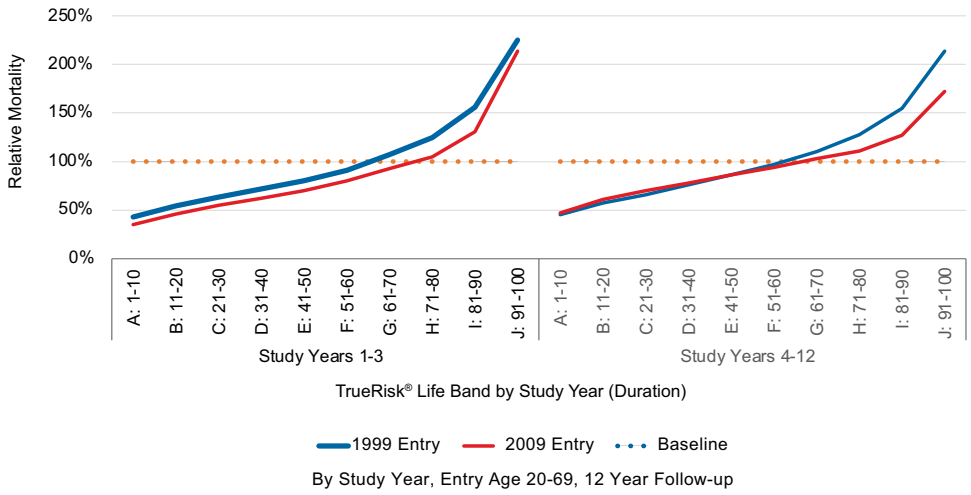


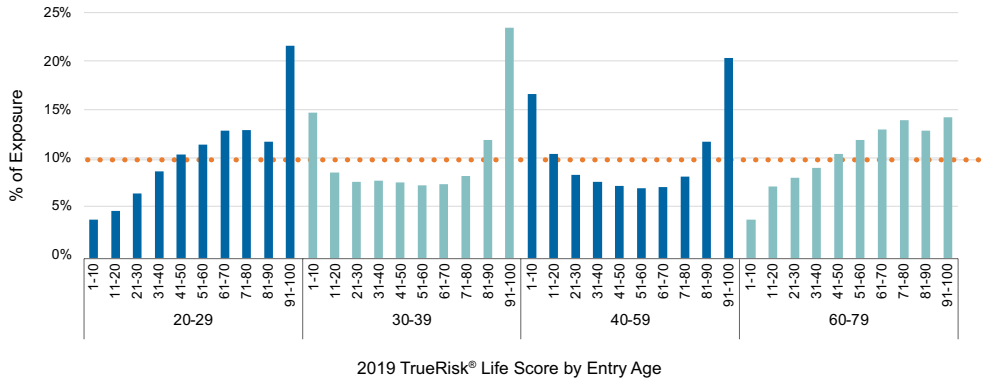
Figure 7 compares the experience of the 1999 and 2009 cohorts using a 12-year follow up to ensure a direct comparison. When comparing relative mortality, it appears that records scored in 2009 have comparable mortality segmentation to those scored in 1999, though some segmentation is lost in the higher scores for later durations.

Death Data Death identification issues could explain a large part of the loss of "lift" in the 2009 cohort in later study years. In Figure 6, segmentation drops off after 2011, a development likely attributable to reduced death identification capabilities. This dynamic may also explain discrepancies in Figure 7, where comparable performance in early study years (1-3) and reduced performance in later years (4-12) may be explained by death identification issues.

Score Distribution The pattern in Figure 7, which shows the mortality within 1999 score bands relative to 1999 overall, might be explained by the shifting distribution of scores in the respective entry years. Because a greater number of records were assigned scores of 91-100 in 2009 than in 1999, these records play a greater role in defining the "average." This is especially visible in study years 4-12 for the 2009 cohort and may be attributed to the drop in lift observed in Figure 7.

Conclusion For the reasons outlined, TrueRisk® Life's performance in recent years may be better than shown in this chart.

Figure 8: Distribution of TrueRisk® Life by Entry Age



The distribution of TrueRisk® Life scores depend on the calendar year and the individual's age. Figure 8 shows the score distribution of individuals in 2019 on the 2019 cohort by age. There is an observed high density of risk scores in ages 59 and under. During model development, the TrueRisk® Life model was calibrated to rank population risks in terms of even risk percentiles, and this chart shows how that distribution has shifted since the model was calibrated.

Risk Segmentation Less Pronounced in the Oldest Ages

Figure 9: Actual to Expected Deaths by TrueRisk® Life and Entry Age

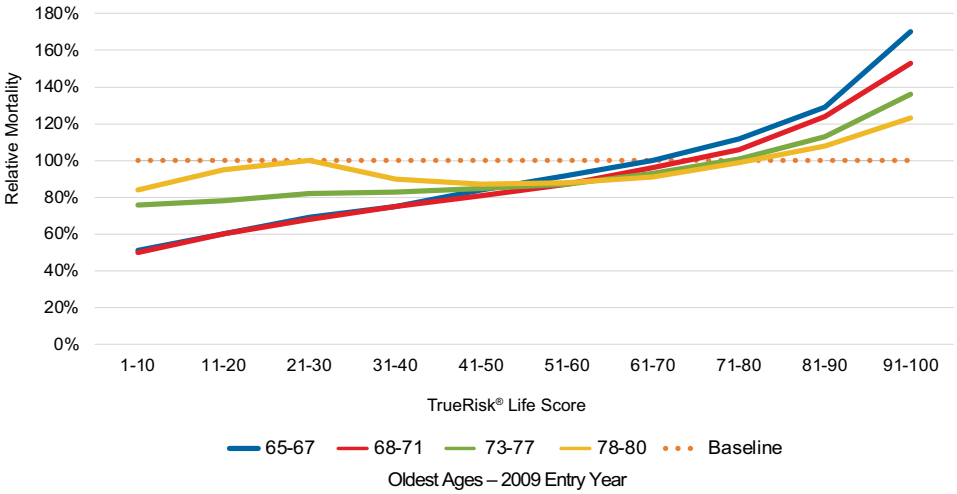


Figure 9 shows TrueRisk® Life's performance on older entry ages, using a 12-year follow up. The experience study for the 2009 cohort incorporated entry ages up to age 80 enabling this analysis, as noted in the Methodology section. Consistent mortality segmentation still occurs for the age group 73-77, but the predictive power of TrueRisk® Life becomes less noticeable for ages 78-80.

Figure 10: Actual to Expected Deaths by TrueRisk® Life Score, Entry Age, and Study Year

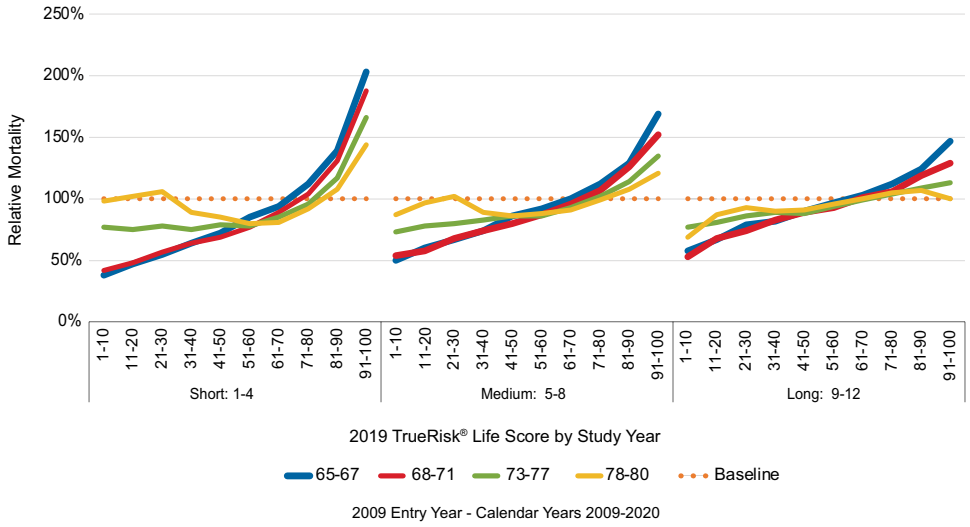


Figure 10 analyzes TrueRisk® Life's ability to segment risk for older people at various study years. Like Figure 9, TrueRisk® Life is more indicative of mortality outcomes in "younger" individuals, with a material difference in predictive power between people 70 and 80. Notably, TrueRisk® Life can segment mortality more than 9 years after scoring for the 70-80 demographic.

TrueRisk® Life Score Varies Over Time

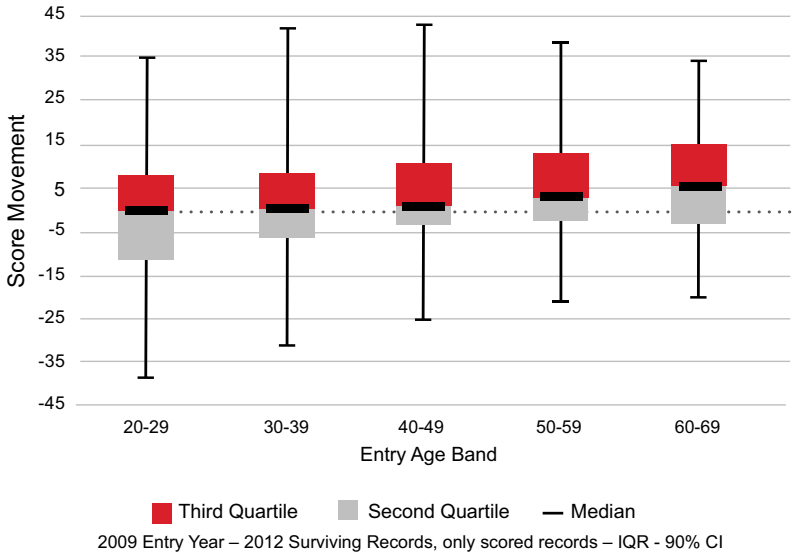
Another area of research interest is to understand how TrueRisk® Life scores vary over time, both at a population level and among individuals. Topics analyzed include score persistence by starting age and starting score.

Figure 11: Score Persistence by Entry Age – 2009 Cohort

Entry Age Band	2008 Average Score	2012 Average Score	Average Score Change	Standard Deviation Score Change
20-29	64.9	63.6	-1.3	21.2
30-39	54.4	56.5	2.1	21.2
40-49	48.2	52.9	4.6	19.8
50-59	48.1	53.8	5.7	18.0
60-69	54.0	60.0	6.0	16.8
Grand Total	**53.7**	**57.0**	**3.3**	**19.9**

Figure 11 shows the average score change by age over the five scoring iterations. In general, younger people's scores fall, while older people's scores rise. This fits an intuitive narrative that younger individuals, who are often less financially established, will mature and improve their position. The least consistent were the oldest, suggesting that there may be a relationship between retirement and credit attributes associated with higher TrueRisk® Life scores.

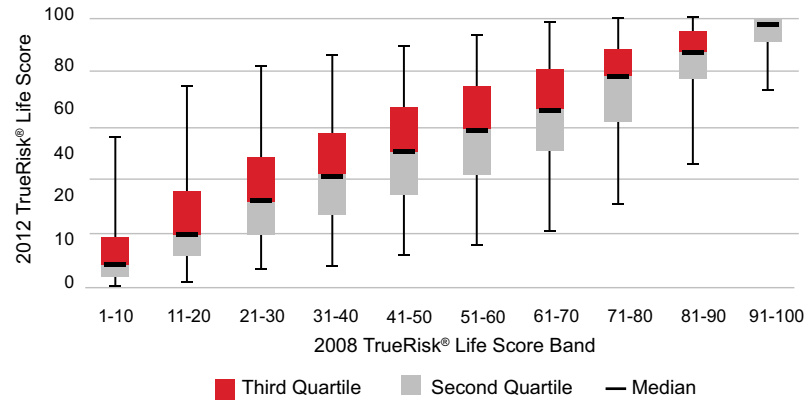
Figure 12: Distribution of Score Change – Four Year Follow Up – By Age



2009 Entry Year – 2012 Surviving Records, only scored records – IQR - 90% CI

Figure 12 shows the "persistence" of scores (assigned from 1-100) for individual records between 2008-2012. For example, an individual who had a score of 32 in 2008, and a score of 30 in 2012, would have a score change of -2. Overall, most people remained within 20 points of their starting score. Persistence was similar across ages when assessed using interquartile ranges.

Figure 13: Distribution of TrueRisk® Life 2012 score by 2008 TrueRisk® Life Score

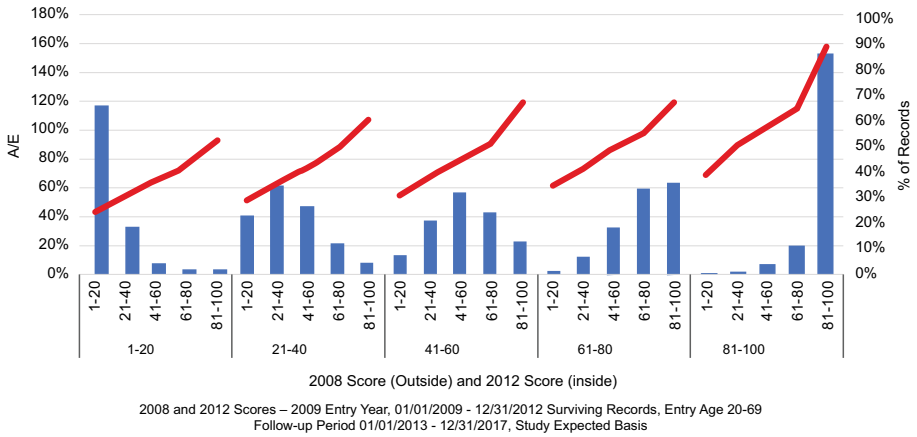


2009 Entry Year – 2012 Surviving Records, only scored records – Entry Age 20-69, 90% CI

Solid score persistence is most apparent in the highest and lowest scores, with considerably less change observed in the extremely high or low scores. This makes intuitive sense, as the 1-10 and 91-100 risk bands have less "room to deviate," since scores are constrained between one and 100.

These distributions give confidence that TrueRisk® Life Scores are most consistent (for individuals) in the areas that they are used for underwriting purposes. A person that receives a score of 91-100 in 2008 is more than 75% likely to remain a 91-100 level risk five years later. Similarly, a person scored in the 1-10 range in 2008 will stay in the range of 1-20 three-quarters of the time.

Figure 14: Actual to Expected Deaths by 2008 and 2012 TrueRisk® Life Scores



2008 and 2012 Scores – 2009 Entry Year, 01/01/2009 - 12/31/2012 Surviving Records, Entry Age 20-69
Follow-up Period 01/01/2013 - 12/31/2017, Study Expected Basis

Analysis of score persistence gave confidence that TrueRisk® Life scores stay close to their starting point, particularly with the highest and lowest scores. That said, an important research imperative was to understand the impact of changing scores on mortality outcomes. Figure 14 shows actual to expected deaths split by scores determined in 2008 and 2012, with the old score (2008) falling outside of the new score (2012) on the x-axis. As expected, people that were deemed riskier in 2012 than in 2008 had higher mortality than those who started at a similar risk level and persisted at their original score (shown by the five red lines sloping up).

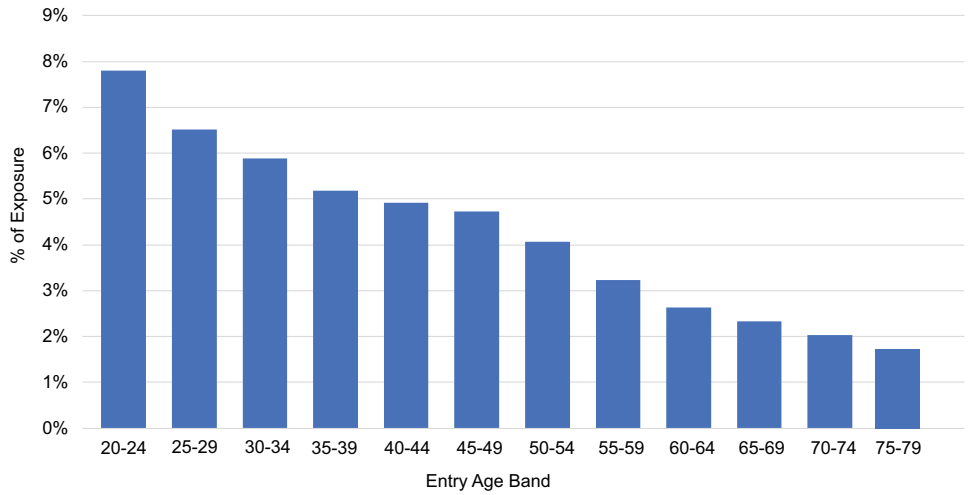
Figure 14 tells two stories regarding TrueRisk® Life. First, people who started as "low" risks and were later reclassified as high risks experienced elevated mortality. Second, it is uncommon for a person to vary materially from their initial risk, even over four calendar years (shown by the blue bars). This is especially true at the highest and lowest scores, which are most consequential to TrueRisk® Life's applications as an underwriting tool. Overall, Figure 14 instills confidence that despite the impossibility of perfect score persistence, score variance has a corresponding impact on mortality experience.

Assessing 'Limited Data' Scores

A feature present in all three cohorts is a TransUnion defined flag identifying records with "thin files" at the time of study entry. According to TransUnion a thin credit file refers to "one that has too few accounts to create a full picture of one's creditworthiness." Having a thin credit file in this dataset is not equivalent to insufficient information to allow for proper assessment of mortality risk by the TrueRisk® Life Score. Unscored individuals with insufficient credit history were excluded from the study. This flag allows analysis of the importance of "credit completeness" on predicted mortality, and whether thin credit poses the same mortality risk in recent years as in the past. Furthermore, this flag provides insight into the relationship between age and credit history accumulation.

Of records scored in 2009, just 5% were flagged as "thin credit file." Most of these "thin" files received scores in the 91-100 range.

Figure 15: Percentage of “Thin Flag” by Entry Age



Prevalence (%) of “Thin File” by Entry Age. Scored records only, 2009 entry year.

Figure 15 explores the relationship between age and prevalence of “thin credit history,” breaking down rates of the “thin flag” attribute. Older people are more likely to have an established history with a credit bureau and are consequently less likely to have a “thin flag.”

Figure 16: Distribution of “Thin Flag” by TrueRisk® Life Score

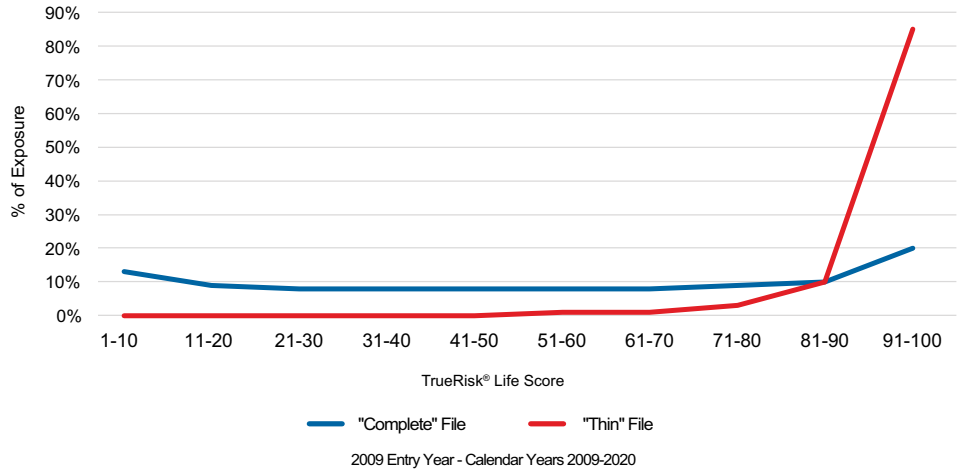


Figure 16 shows that when an individual has a thin credit history, they are over 80% likely to have a score between 91 and 100. It appears that a principal motive for an individual receiving a score of 91-100 is somehow associated with limited credit usage. However, of the records with a score of 91-100, only 18% were flagged with “thin credit history.” This suggests that there are many other drivers contributing to a very high score.

Figure 17: Actual to Expected Deaths by TrueRisk® Life Score, Entry Age, and Thin Flag Indicator

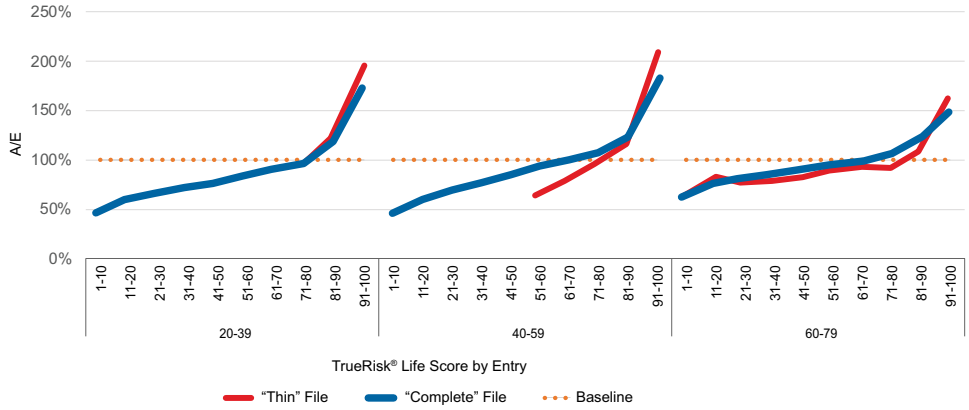


Figure 17 compares the performance of TrueRisk® Life scores by the thin credit file flag. Of records scored in 2008 and followed to 2020, lift was generally comparable (with the exception noted below) in records impacted by "thin file" characteristics. Actual-to-expected mortality rates are only shown when there is a credible count of deaths for each cell.

At the highest levels of risk (scores 91-100), having a thin file appears to be additionally risky, after controlling for age. Even for younger records, people that were assigned high scores due to limited data seem to carry additional risk.

RGA's Take

While studies of insured blocks, such as the dozens completed by RGA, are most relevant to carriers' use of TrueRisk® Life, the results of this study are perceived very favorably by RGA. The results of this study reinforce that TrueRisk® Life is a stable, long-term predictor of mortality. While any scoring model may see score changes over time for a given individual, we were encouraged by the overall persistence of the TrueRisk® Life score over time, with the study results suggesting that, in aggregate, the majority of individuals qualifying for a certain underwriting action based on their TrueRisk® Life score (e.g. qualification for accelerated underwriting) would likely maintain a score within that range years later. We were also pleased to discover that TrueRisk® Life demonstrates meaningful mortality segmentation at higher ages (70-80). Furthermore, we believe that the performance observed in this study is likely understated relative to what insurance carriers would see in their experience if deaths are disproportionately underreported at the highest scores.

While the results in this study also show some change in TrueRisk® Life score distributions across the U.S. population from the previously studied 1998 archive: the dozens of insured blocks RGA has analyzed in more recent years suggest that this shift occurred many years ago and that score distributions have since stabilized. Therefore, any change in the score distributions shown in the

U.S. population should already be reflected in carriers' use of TrueRisk® Life and we wouldn't expect any further action to be necessary.

In conclusion, the results of this study reaffirm our prior assessment of TrueRisk® Life and further reinforce the value it brings as a tool for risk assessment.

Citations

Rushing, S., and Kueker, D. (2019, March 28). TransUnion's TrueRisk® Life: Creation and Validation of the Industry's Leading Credit-Based Insurance Score. rgare.com. Retrieved March 1, 2022, from https://www.rgare.com/knowledge-center/media/articles/TransUnion-s-truerisk-life-creation-and-validation-of-the-industry-s-leading-credit-based-insurance-score