Milliman Risk Score 2.0 – stratifying mortality risk using prescription drug information

Predictive models and life insurance

Munich Re assessed the Milliman Rx Risk Score, a predictive modeling tool developed and owned by Milliman that assesses mortality risk using an individual's prescription drug information. Insurers considering prescription-drug-based scores should begin with a retrospective validation study on their own experience data. Munich Re can assist carriers with the retrospective study, advise on changes to mortality assumptions and recommend ways to incorporate the scores to streamline the underwriting process.

Executive summary

The Milliman Rx Risk Score is a proprietary scoring algorithm that uses prescription drug history to predict the mortality risk of individuals relative to other individuals of the same age and gender. In 2017, Munich Re assessed Rx Risk Score 1.0 and determined the scores are predictive of mortality for the U.S. insurance applicant population. Recently, Milliman enhanced their Rx Risk Score by incorporating additional data and more sophisticated predictive modeling techniques to assign a score to each individual.

Milliman provided Munich Re with 25 million lives sampled from the U.S. general insurance applicant population which includes life,

health, LTC, DI, final expense and Medicare supplement. Compared with the data used to develop the first Rx Risk Score, the development of Rx Risk Score 2.0 is comprised of 12 million more lives, two more years of data with two additional years of duration, and double the number of deaths. Applicants who were not found in the prescription history query were classified as "No Hit" in the most severe drug priority field. Applicants who were found in the prescription history query, but with no prescription fills were classified as "Eligibility Only".

Munich Re performed an analysis of Rx Risk Score 2.0 and confirmed it is predictive of mortality for the U.S. insurance applicant population. Munich Re recommends replicating the study on a company-specific insured dataset to help assess the value of the Milliman Rx Risk Score; a company-specific insured population is not expected to have identical underlying characteristics as this insurance applicant population.

Life insurers interested in the Milliman Rx Risk Score should conduct a retrospective study in order to calibrate the tool to the carrier's own underwriting paradigm. This process will help carriers balance the score with expected mortality with respect to their unique target markets, distribution channels, and other underwriting tools.

Key findings

Primary high-level findings include the following:

- Relative mortality risks increase as the Milliman Rx Risk Scores increase.
- Risk Score 2.0 has more lives with higher scores and more lives with lower scores compared to the prior version, allowing carriers to identify more lives with better mortality.
- The Milliman Rx Risk Score stratifies mortality risk across attributes provided by Milliman, and it is especially effective at identifying high mortality risk at earlier durations.
- The Milliman Rx Risk Score effectively stratifies mortality risk across age groups and the distribution of Rx Risk Scores is relatively even across age groups.
- It might be particularly effective to use the Milliman Rx Risk Score to identify high mortality risk when less medical data is available.
- The Milliman Rx Risk Score is not simply a measure of the severity of an applicant's drug history.
- The clinical mortality rules can be used with the Rx Risk Score to flag cases where the applicant is taking medication for conditions associated with higher mortality.

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Methodology

Munich Re assessed the effectiveness of the new Milliman Rx Risk Score in stratifying the mortality risk profile of a pool of 25 million applicants with entry ages 0 - 100. Each life entered the study between the first quarter of 2005 and the last quarter of 2016. Deaths were sourced from the Social Security Death Master File and third party proprietary databases. The study population is comprised of 468,491 deaths out of 104 million exposed life-years.

The expected mortality basis was taken from the 2015 VBT primary select and ultimate ANB tables split by age and gender with a 1 percent mortality improvement. We did not have the smoking status of each applicant, so we used an 85 percent non-smoker/15 percent smoker blend of the smoker distinct tables.

Munich Re completed additional analyses of relative actual to expected ratios (A/E) by various factors (e.g., age, gender, duration,

line of business, most severe drug priority, and clinical mortality rule flag) to assess whether the mortality risk stratification by the Milliman Rx Risk Score is influenced by those factors.
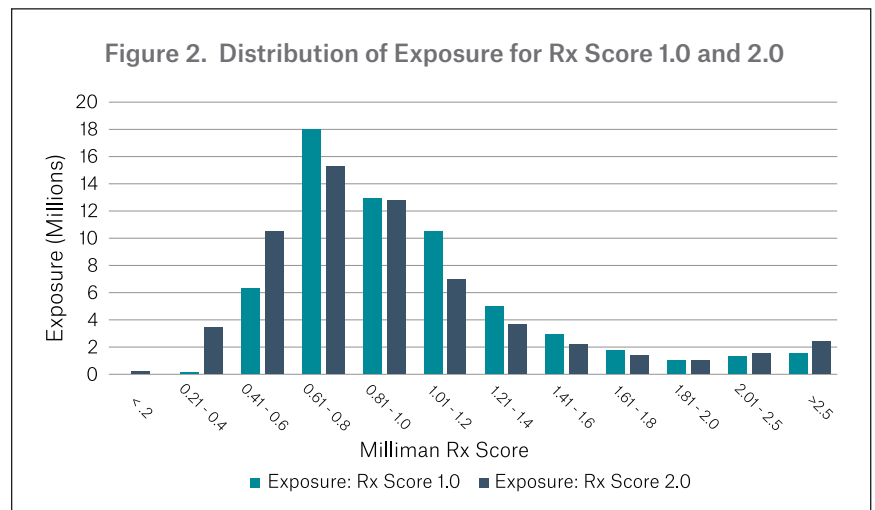
Overall Results

Figure 1 is a high-level overview validating the Milliman Rx Risk Score 2.0's ability to stratify mortality risk. Lives with higher scores have higher mortality risk, while lower scores correspond with lower mortality risk.

Figure 1. Relative A/E vs Rx Score with Exposure for Rx Score 2.0
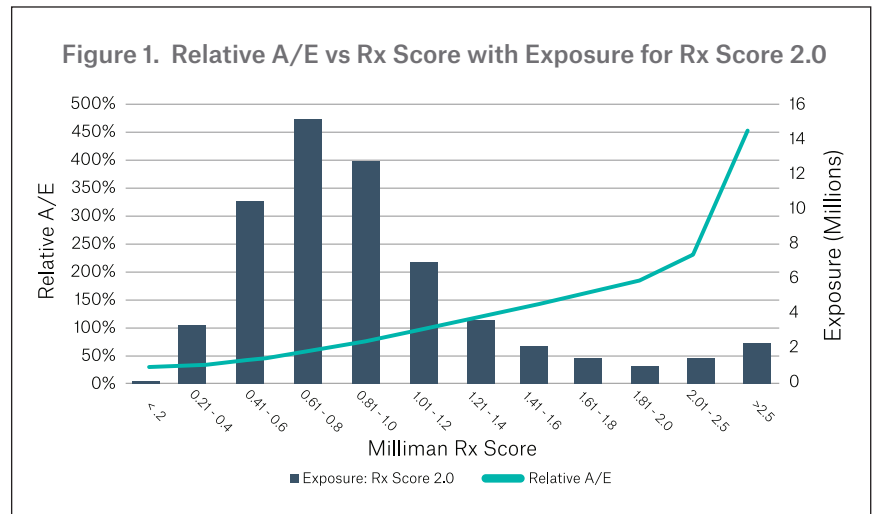
Exposure

Figure 2 shows the distribution of risk scores for the exposures used to develop Risk Score 1.0 and Risk Score 2.0. We observe that there is a wider distribution of exposures in Risk Score 2.0: there are more lives that have a risk score greater than 2.5 and more lives that have a risk score less than 0.6.

This means that Risk Score 2.0 allows carriers to identify more lives with better mortality.

Figure 2. Distribution of Exposure for Rx Score 1.0 and 2.0

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Age

Figure 3 shows the distribution of
the Milliman Rx Risk Scores within
each age group (excluding Eligibility
Only and No Hit); the Rx Risk Score
is controlled for age. With Risk Score
1.0, the proportion of low scores
increases as age increases and
flattens out after age 70.

With Risk Score 2.0 we see that the
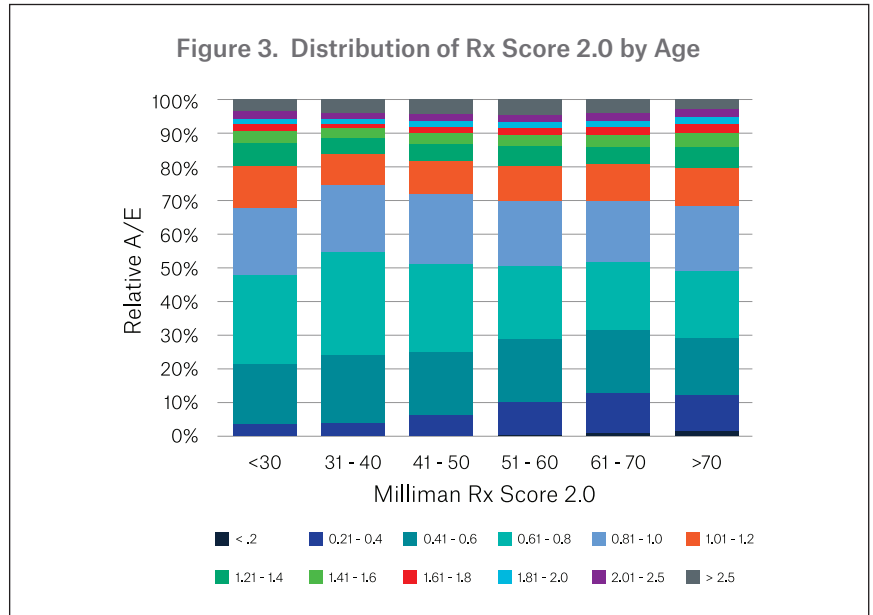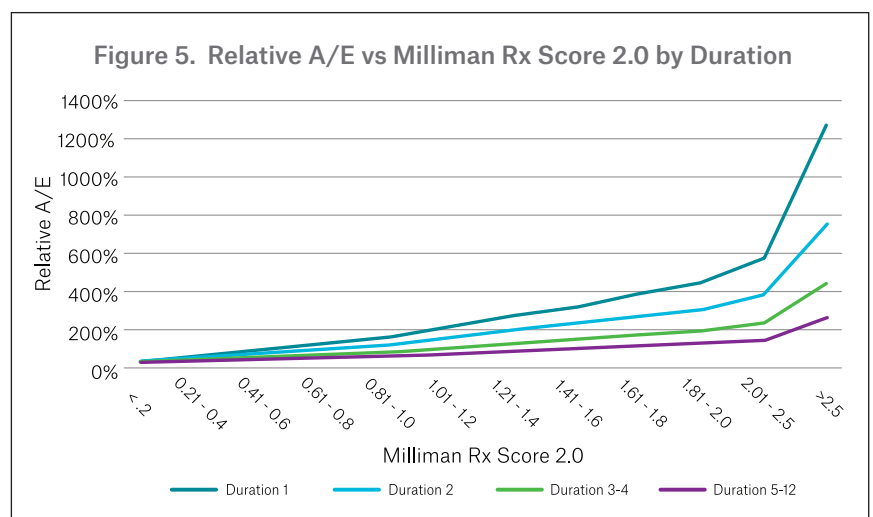distribution of scores is about the
same across age groups.

Figure 3. Distribution of Rx Score 2.0 by Age

Figure 4 demonstrates the mortality
risk segmentation of the Milliman
Rx Score by age group. All age groups
follow the same pattern, where
mortality risk increases as Rx scores
increase. From the chart, it can be
observed that the population of lives
age > 70 has a lower mortality risk
for high scores compared to the
rest of the study population with
high scores.

Figure 4. Relative A/E vs Milliman Rx Score 2.0 by Age
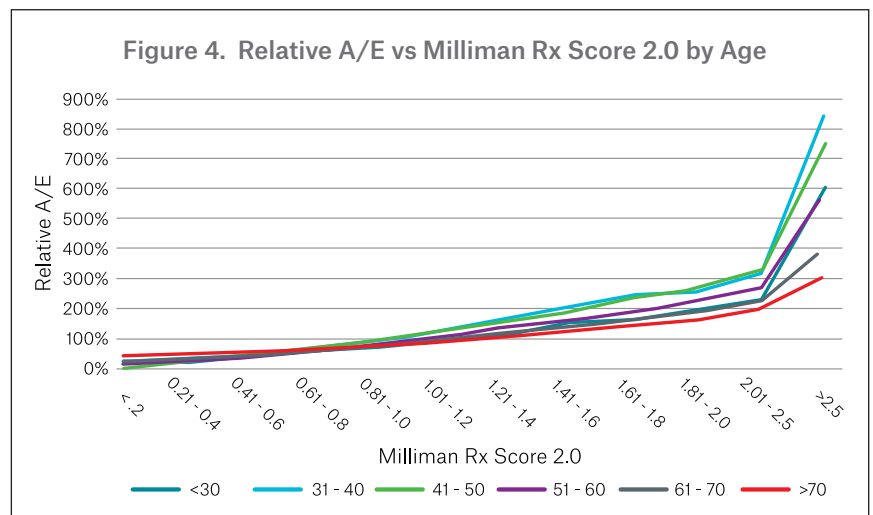
Duration

From **Figure 5**, we can see that
the effectiveness of the Milliman
Rx Score is consistent for varying
durations. The difference in mortality
risk between the durations is more
evident for higher scores. High
scoring lives have a higher mortality
risk in the early durations, which
then decreases significantly in
later durations.

Figure 5. Relative A/E vs Milliman Rx Score 2.0 by Duration

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Line of Business

The Milliman Rx Risk Score stratifies mortality risk across different lines of business as shown in **Figure 6**.

Most Severe Drug Priority

The study population (excluding Eligibility Only and No Hit) were assigned one of three "most severe drug priority" ratings – green, yellow, and red. A green rating indicates the applicant has a prescription history with only drugs corresponding to low mortality risk. Similarly, a yellow rating indicates the applicant has a prescription history with drugs corresponding to moderate mortality risk or lower. A red rating indicates the applicant's prescription history contains a drug corresponding to high mortality risk.

As illustrated by **Figure 7**, the Milliman Rx Risk Score successfully segments mortality risk for applicants with red and yellow most severe drug priority ratings. We observe the mortality risk is significantly higher for green ratings for scores greater than 2.5; this is because there is a very low number of deaths in this group (only two deaths).

Because the Milliman Rx Risk Score uses a multivariate approach to incorporate information from the Rx history, it provides additional mortality segmentation, especially for higher mortality risks, over using the green/yellow/red drug classification alone.

If we expand the analysis to include applicants with prescription history classifications of No Hit and Eligibility Only as well, we observe that applicants with No Hit have higher relative mortality compared to applicants with Eligibility Only. **Table 1** shows the relative mortality ratios for all prescription history classifications.

Figure 6. Relative A/E vs Milliman Rx Score 2.0 by Line of Business

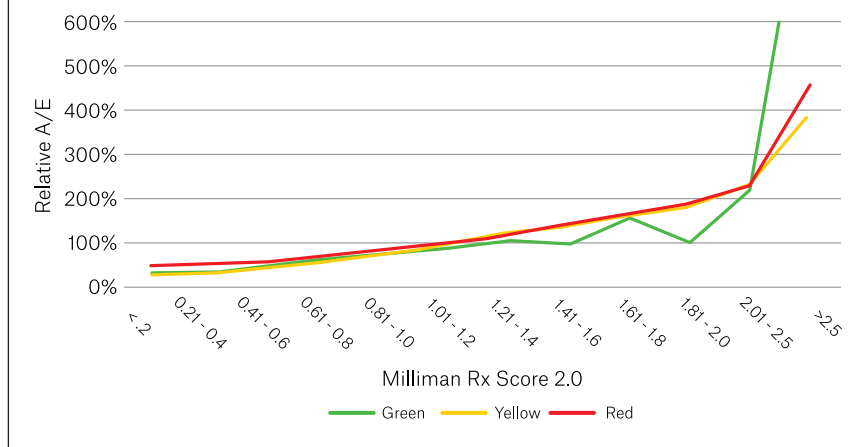Figure 7. Relative A/E vs Milliman Rx Score 2.0 by Drug Priority

Table 1		
Prescription History Classification		**Relative Mortality Ratio**
No Hit		109%
Eligibility Only		99%
Rx Found	Green	66%
	Yellow	72%
	Red	157%
Grand Total		**100%**

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Clinical Mortality Rule Flag

Milliman has incorporated a clinical
mortality rule to flag applicants
(excluding Eligibility Only and No
Hit) who are taking medication for
a condition associated with adverse
mortality. This is a condition-based
flag that can be useful when there
is little data available or when
evaluating new drugs. The rules can
be customized for each company. In
this study, 2 percent of all applicants
have a clinical mortality flag of 1
while 3 percent of applicants with
an Rx Score have a clinical mortality
flag of 1.

Figure 8 demonstrates the mortality
risk segmentation of the Milliman
Rx Score by the clinical mortality
rules flag. From the chart, it can be
observed that the population of lives
where the clinical mortality rule flag
equals 1 has a higher mortality risk
for all scores compared to the rest
of the study population where the
flag equals 0.

Summary

Munich Re concludes the Milliman
Rx Risk Score 2.0 is an effective
predictor of mortality for the U.S.
insurance applicant population. The
Milliman Rx Risk Score 2.0 stratifies
mortality risk across multiple
attributes and successfully isolates
high risk applicants for all lines of
business. It is especially effective
at identifying high mortality risk
at earlier durations. Furthermore,
mortality risk segmentation is
effective across all ages, even for
older applicants who are more prone
to require severe drug prescriptions.
As such, the Milliman Rx Risk
Score is not simply a measure
of the severity of the applicant's
drug history. The score might be
particularly effective in identifying
high mortality risk when little
other medical data is available,

Figure 8. Relative A/E vs Milliman Rx Score 2.0 by Clinical Mortality Rule Flag
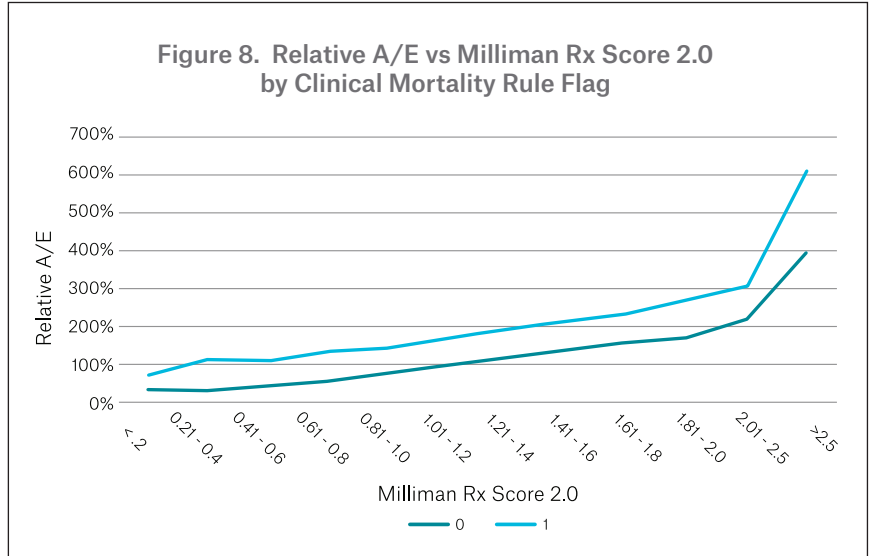
for example, in simplified issue
programs. clinical mortality rules
can further segment mortality to
flag individuals who are taking
prescriptions for conditions with
higher mortality risk and these
rules can be customized to fit the
experience of an individual carrier.
Finally, a company-specific insured
population is not expected to have
identical underlying characteristics
to this insurance applicant
population; we recommend each
carrier perform a retrospective
study to best assess the value
and application of the Milliman
Rx Risk Score.

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NOT IF, BUT HOW