Institut für Finanz- und Aktuarwissenschaften
ifa

Mortality Distributions for Multiple Impairments

- Jochen Russ

- Washington D.C., November 2016

Agenda

Introduction: How do LE-Providers work?

Multiple Impairments

Examples where Medical Experts have a Solution

How Statistics can help

Case Study

Summary, Limitations and Outlook

Introduction: How do LE-Providers work?

Basic Idea (!) of Life Expectancy Estimation

1. A so called **base table** gives annual mortality probabilities (and thus the life expectancy) for an average person
   - average could be e.g. average male US-citizen, average female non-smoking insured, …
2. **Medical assessment**: Is the mortality of a certain individual above or below average?
   - Quantify by how much (debits/credits)
   - 75 debits means: Annual mortality probability of individual = 1.75 * average mortality probability
   - → These mortality probabilities are used to calculate e.g. the individual life expectancy.

Source: My presentation "Evaluating Life Expectancy Estimates" at the 2005 Fasano-conference

Introduction: How do LE-Providers work?

Back in 2005 I listed a set of questions you should ask your LE-provider:

- Is the base table appropriate for the considered business?
- Does the debiting reflect peculiarities of the elderly?
- Is the quality of the LE projections monitored on a regular basis?
- **How are multiple impairments considered?**

Focus of today's presentation

Source: My presentation "Evaluating Life Expectancy Estimates" at the 2005 Fasano-conference.
Note: In the 2005-presentation, I have used the terms "co-morbidity" and "multiple impairments" interchangeably.

Agenda

Introduction: How do LE-Providers work?

Multiple Impairments

Examples where Medical Experts have a Solution

How Statistics can help

Case Study

Summary, Limitations and Outlook

Multiple Impairments

What is it?

Sometimes, an insured has more than just one impairment.

In such a case, an LE-provider would typically …

- assess each impairment separately,
- come up with a respective number of debits for each impairment,
- and finally aggregate these debits.

The important question is: **How should these debits be aggregated?**

Multiple Impairments

Illustrative Example

Assume a male insured aged 85 who has a **severe impairment (A)**.

- If the insured had only impairment A, this would result in **200** debits.

The insured has three more **minor health issues (B, C, and D)**.

- If the insured had only impairment B, this would result in **50** debits.
- If the insured had only impairment C, this would result in **50** debits.
- If the insured had only impairment D, this would result in **25** debits.

The important question is: **How should these debits be aggregated?**

- The **naïve** approach: Each impairment increases the mortality probability. If they are all present at the same time, they should simply be added up. **200 + 50 + 50 + 25 = 325**
- The **primary impairment only** approach: The severe impairment is dominating. The insured will die from that. The other impairments are irrelevant. **200 + 50 + 50 + 25 = 200**
- The **balanced** approach: The severe impairment is dominating. The other impairments are less relevant, but will have some kind of influence. **200 + 50 + 50 + 25 = some number between 200 and 325**
- **Murphy's** approach: Some of the impairments interact in a way that things get much worse. **200 + 50 + 50 + 25 = some number larger than 325.**

Multiple Impairments

Which approach is correct?

Each approach can be correct in some circumstances.

Common sense suggests that…

- the naïve approach is usually not the best solution,
- the primary impairment only approach is only suitable if the primary impairment is very severe,
- most of the time, the balanced approach would yield the best result. **But it is not intuitively clear, which weighting should be given to non-primary impairments**.
- Murphy's approach should be applied in those cases where the combination of two impairments is worse than the sum of the parts.
  - E.g., the combination of heart failure and renal failure on dialysis is particularly fatal, as the strain that dialysis puts on the heart cannot be taken by a weak heart.

Multiple Impairments

Why is it important?

- Multiple impairment cases are often high ages and high debit cases, i.e. short LEs.
- On the one hand, these are cases where investors can offer a price that significantly exceeds the surrender value. Therefore such cases are likely to close.
- On the other hand, the “sensitivity” of the investor’s return with respect to the LE is particularly high.
  - Therefore a wrong assessment has a particularly high impact.
  - See example on slide 18.

Agenda

Introduction: How do LE-Providers work?

Multiple Impairments

Examples where Medical Experts have a Solution

How Statistics can help

Case Study

Summary, Limitations and Outlook

How Statistics can help

If data are available, statistical methods are helpful, e.g. in order to …

- … confirm hypotheses from medical research.
  - E.g., if medical research/common sense suggest that for certain combinations and level of severity of impairments one should only consider the primary impairment, one can analyze if mortality for such cases is consistent with this assumption.
- … come up with a new hypothesis, where no medical research exists.
  - For example if you expect that in most cases the balanced approach is correct, some questions remain:
    - How much weight should be given to the other (i.e. non primary) impairments?
    - Are there differences between different “segments” of the population?
  - We have analyzed this question based on selected cases from Fasano Associates’ database and will give the results in the remainder of this presentation.

Agenda

Case Study

The following case study is based on 209 cases from Fasano Associates' database.

- The cases were selected as follows:
  - Age > 85
  - Total number of debits > 100
  - At least two impairments
  - Originally underwritten after January 1, 2008.
- For the purpose of this analyses, the cases were re-underwritten based on Fasano Associates' current mortality tables and underwriting guidelines.

Case Study

We have analyzed the considered cases in total as well as segmented by type of primary impairment (PI).

We use Actual/Expected as a metric for the quality of underwriting and first look at the naïve and the primary impairment only approach.

The results are as follows:

	Naïve	PI Only
A/E ratio (all cases) n=209	96%	127%
A/E ratio (Cardiovascular cases) n=61	94%	140%
A/E ratio (Dementia cases) n=75	101%	131%
A/E ratio (Other cases) n=73	92%	116%

The naïve approach appears slightly too aggressive on average but it seems to work rather well with dementia cases.

The PI only approach appears too conservative.

ifa

Case Study

The following weighting of the non-primary impairments leads to an A/E of 100%:

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	**80%**
A/E ratio (Cardiovascular cases) n=61	94%	140%	**80%**
A/E ratio (Dementia cases) n=75	101%	131%	**100%**
A/E ratio (Other cases) n=73	92%	116%	**55%**

Our analyses indicate that non-primary impairments should be weighted with about 80% on average. But there are strong differences between the different segments.

ifa

Case Study

The following results use a segmentation of the cases by “dominance of the primary impairment”:

(1) Number of debits for the PI > 2* debits for all other impairments.

(2) Number of debits for the PI > debits for all other impairments but < 2x debits for all other imp.

(3) Number of debits for the PI < debits for all other impairments.

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	**80%**
(1) n=93	96%	111%	**62%**
(2) n=71	94%	131%	**74%**
(3) n=45	100%	173%	**100%**

Again, there are strong differences between segments.

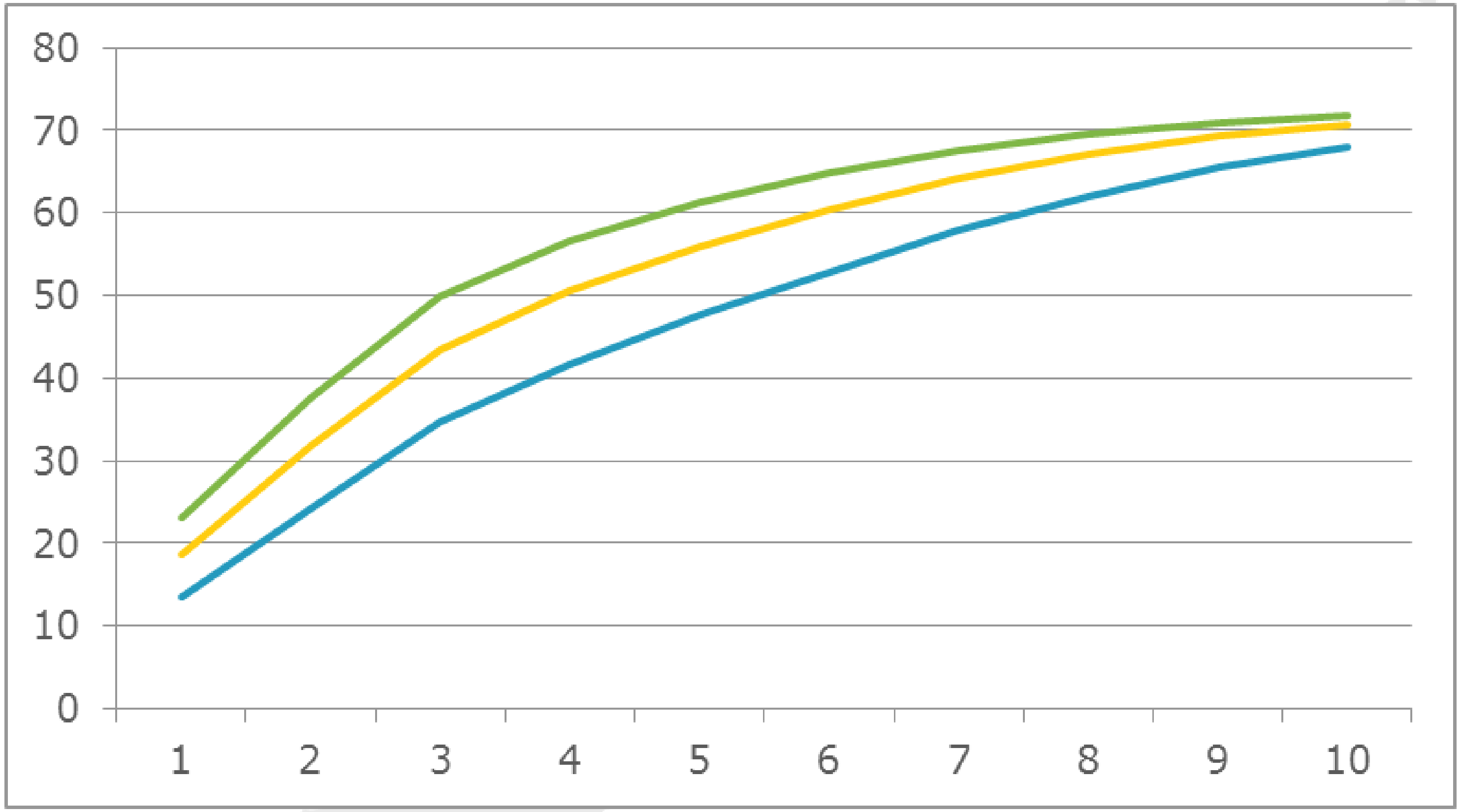
The more pronounced the non-primary impairments are (relative to the primary impairment), the more weight should be given to them.

Case Study

Impact on expected number of deaths

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	**80%**
A/E ratio (Cardiovascular cases) n=61	94%	140%	**80%**
A/E ratio (Dementia cases) n=75	101%	131%	**100%**
A/E ratio (Other cases) n=73	92%	116%	**55%**

The curves show the expected number of deaths after 1, 2, 3,…, 10 years for the 73 "other" (i.e. non cardiovascular and non-dementia) cases under the naïve (green), primary only (blue), and "balanced" (yellow) approach



If a wrong approach is used in underwriting, observed mortality might significantly deviate from expected mortality.

Case Study

Impact on policy return

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	80%
A/E ratio (Cardiovascular cases) n=61	94%	140%	80%
A/E ratio (Dementia cases) n=75	101%	131%	100%
A/E ratio (Other cases) n=73	92%	116%	55%

We have priced an exemplary policy:

- male insured, aged 85, non-smoker, death benefit USD 10m, policy has "typical" premiums
- We have assumed that the insured has impairments as in the example on slide 6:
  - Primary impairment: 200 debits
  - 3 other impairments with 50, 50, and 25 debits, respectively
- We have assumed that an underwriter (wrongfully) uses the naïve approach and issues an LE of 63.1 months (mean) / 62 months (median) based on 325 debits whereas the correct approach would be to give the non-primary impairments only a weighting of 55%.
  - I.e. the correct number of debits would be 200 + 55% of (50+50+25) = 269 debits resulting in an LE of 68.8 months (mean) / 68 months (median).

If an investor prices the policy at an expected yield of 12% using the wrong LE, the expected return would in fact only be 9.02%.

If an investor prices the policy at an expected yield of 8% using the wrong LE, the expected return would in fact only be 5.64%.

Agenda

Introduction: How do LE-Providers work?

Multiple Impairments

Examples where Medical Experts have a Solution

How Statistics can help

Case Study

Summary, Limitations and Outlook

Summary

Our results strongly indicate that cases with multiple impairments need to be underwritten carefully.

- The impact of non-primary impairments appears to depend on the type of primary impairment and on the "intensity" of the primary impairment relative to the non-primary impairments.
  - Non-primary impairments appear to…
    - have the highest impact if the primary impairment is dementia,
    - have a somewhat smaller impact if the primary impairment is cardiovascular,
    - need to be significantly discounted in other cases.

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	**80%**
A/E ratio (Cardiovascular cases) n=61	94%	140%	**80%**
A/E ratio (Dementia cases) n=75	101%	131%	**100%**
A/E ratio (Other cases) n=73	92%	116%	**55%**

  - Our findings also indicate that non-primary impairments should be discounted particularly strongly if the primary impairment is particularly severe when compared to the non-primary impairments.

	Naïve	PI Only	Weighting that results in A/E = 100%
A/E ratio (all cases) n=209	96%	127%	**80%**
(1) n=93	96%	111%	**62%**
(2) n=71	94%	131%	**74%**
(3) n=45	100%	173%	**100%**

The effects seem to be very pronounced ("optimal weighting" can be as low as 55%). But also very heterogeneous (results differ heavily between the different subpopulations).

Limitations

The results are of course preliminary and of limited statistical credibility because of the rather low number of cases.

- Due to the rather time consuming re-underwriting, an analysis of a larger pool of data would require significantly more time.

The results of the different segmentations (by type of impairment and by “intensity” of the primary impairment) cannot simply be aggregated.

- Multivariate statistical analysis (and more data) are required.

Also, the results might need to be re-calibrated.

- The “optimal weighting” of the balanced approach was chosen such that it leads to an A/E-ratio of 100%.
- Of course, this only makes sense if the A/E for single impairment cases is also 100%. We have assumed (but not verified) that this is approximately true.
- Otherwise, this weighting would not only adjust for multiple impairments but also correct for the imperfections of the underwriting of single impairment cases.

Outlook

If more data were available, additional analyses could create additional insights, e.g.

- other segmentations (by age, gender, more impairment buckets, …),
- multivariate analyses,
- etc.

Also, one could analyze the shape of the mortality curve, i.e. the question if the "structure of the excess mortality" is different for certain combinations of impairments.

- So far, we have assumed, that debits convert into a mortality multiplier that is constant over time.
  - E.g. 150 debits → multiply all mortality probabilities from the base table by a factor of 2.5 (i.e. 100% base mortality + 150 debits = 250% of base mortality)
- We have only analyzed, which multiplier leads to the best fit of actual and expected mortality.
  - The shape of the mortality curve is automatically implied by the shape of the base table and the multiplier.
- If more data were available, one could also analyze if certain combinations of impairments result in a different shape of the mortality curve, e.g. a higher multiplier in early years that wears off over time, etc.

Contact

apl. Prof. Dr. Jochen Ruß
Managing Partner
+49 (731) 20644-233
j.russ@ifa-ulm.de