New Mortality Assumptions for Pension Business in Spain

The theme of longevity is woven throughout the entirety of J.R.R. Tolkien's 1954 novel "The Lord of the Rings". The ring has the power to extend the life of the wearer. However, this is done at a great cost, as Frodo Baggins, one of the central characters, experiences throughout the epic novel. Longevity, or the risk of living longer than expected, is something that comes at a cost.

However, longevity itself could be considered an achievement among societies able to extend the lifespan for a considerable part of its population by reducing the rate at which people die. A prominent example of this is the reduction of deaths resulting from cardiovascular diseases in the recent past. But, as commendable as it may seem, longevity may also become a societal risk. This risk can be understood from either an individual perspective, like the emotional cost of seeing good friends pass away, or an economic perspective, as in the financial cost of maintaining good health as we age. The risk can also be viewed from a collective perspective, as the financial burden on public and private pension systems grows if people live on average longer than expected. A primary task of governments and private institutions carrying this risk is to quantify it in order to develop actionable policies that will guarantee their own financial stability.

Following this very important task, in 2020 the Spanish insurance regulation authority DGSFP revised and approved new mortality assumptions (PER2020) for pricing/reserving pension business in Spain.[1] These new assumptions aim at completely replacing the prior mortality assumptions (from the year 2000) until the end of 2024.

This article analyzes, summarizes, and contextualizes the construction of the new table and corresponding mortality trend to better understand its implications for the insurance sector. We put special attention comparing different aspects of the Spanish table with the German Table DAV 2004R. We do this, since the authors of the Spanish table followed a similar methodology as the one used in Germany.

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Content

Construction of the 2nd Order Base Mortality Table

Ages greater than 60 and below 93

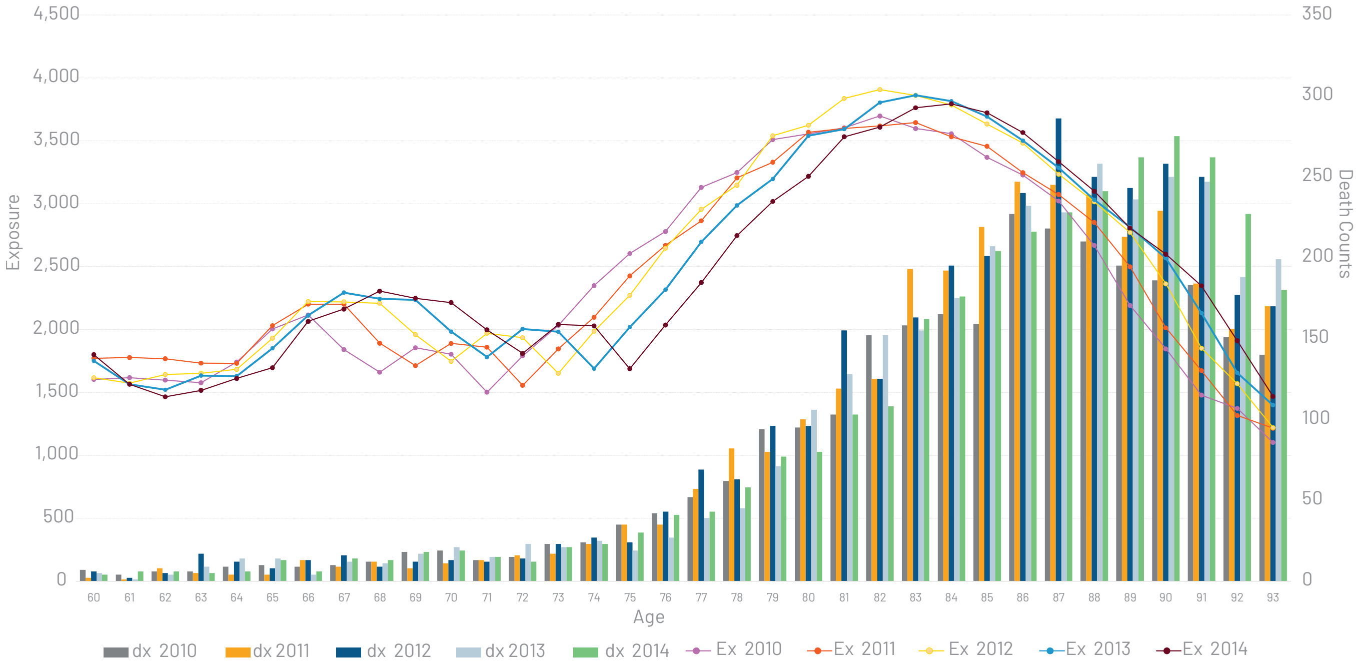
The 2nd order base mortality table can be considered as a best estimate of the mortality risk of a population for an underlying base year. Specifically, for the PER2020 2nd order, raw mortality rates for ages greater than 60 and below 93 were derived using age- and gender-dependent exposure (number of person-years) and death counts observed on a book of group annuities[2] in the payout stage for years 2010-2014. The exposure-weighted average resulted in choosing 2012 as the base year. One observation about the exposure used is the presence of a considerably older female population, which may be partially explained by "inherited" annuities when one of the husband dies. Such an exposure profile may change in time as younger generations, with a higher percentage of working females, retire:

Table 1 — Average age in exposure used for base table PER2020

Average Age	Insured	Deaths
Male	74.45	82.87
Female	78.95	87.08

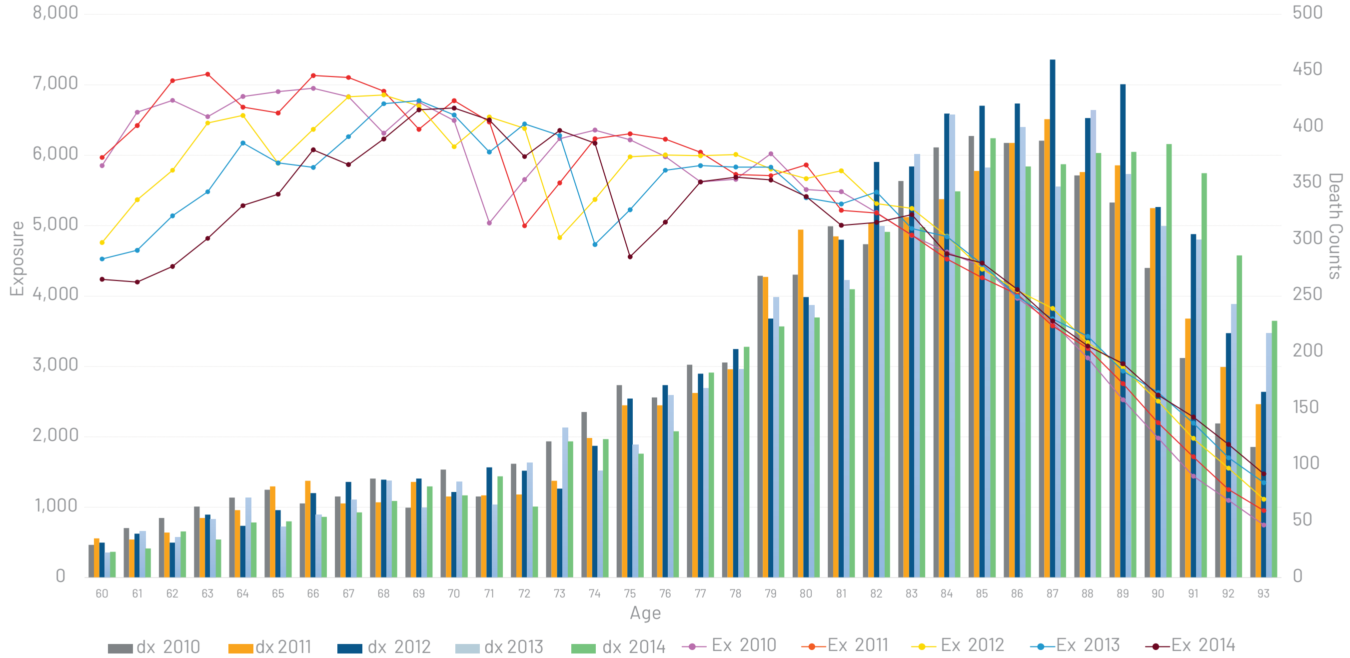
Source: Gen Re own presentation, based on DGSFP, 2019[3]

Figure 1 — Male exposure and death counts used for base table PER2020



Source: Gen Re own visualization, based on DGSFP, 2019[4]

Figure 2 — Female exposure and death counts for base table PER2020



Source: Gen Re own visualization, based on DGSFP, 2019[5]

Additionally, reflecting on the information used for deriving the raw mortality rates we can observe:

1. No individual business was considered. This fact is relevant when using the tables for pricing/reserving certain given pieces of business. The reason is that individual business may render different claims experiences than group business.
2. No adjustment for the socioeconomic mix was used. This may render additional risks since it is known that mortality can vary considerably across socioeconomic deciles.[6] This may also be reflected when pricing for groups' different occupational classes.
3. Exposure and claims used are counts and not sum-weighted. Sum-weighted mortality rates tend to be lower than counts-weighted death rates. One widely accepted interpretation of this fact is that sum-weighting may be a proxy to approximate the socioeconomic status of a group. The higher the sums insured, the lower the mortality rate.
4. The base mortality table is ultimate, and no selection factors were derived. This fact may play an important role for some age bands and sectors of the insured population, where we tend to observe lower mortalities for the same age depending on whether the person is in the first years of the pay-out phase. For example, the German table DAV2004R considers a lower mortality for the first five years of the annuity and reach ultimate rates from the sixth year onwards.[7]

Ages below 60

For ages below 60, mortality rates from general population mortality provided by the INE[8] were adjusted to cope with the so-called "mortality-gap". This "mortality-gap" can be defined as the observed ratio between the insured population mortality and the general population mortality. Specifically, the mortality-gap for group pension business for ages 60 to 62 was estimated at 71.15% for male and 79.51% for female in Spain. These factors were applied for all younger ages. Although mortality rates for ages below 60 in the context of annuities in the payout phase may play a minor role, these ages are important for contracts in the saving phase. From the German experience during the construction of the DAV2004-R mortality tables, we know that mortality rates between saving and payout phase may be different. For that reason, while in Germany we have different tables to cope with this situation, in Spain we have only one base table, which may render further uncertainties for younger ages.

Ages above 93

The available information for older ages is normally not sufficient to derive stable mortality rates. Therefore, it is common to extrapolate mortality rates based on an age band where information is credible enough. Specifically, for the Spanish tables, using ages 80 to 93 a four-parameter logistic model was estimated $q_x \sim logit(a, \alpha, \beta, b)$

$$q_x = 1 - \exp\left(-\left(\frac{\beta \exp(bx)}{1 + \alpha \exp(bx)} + c\right)\right)$$

to extrapolate for ages 94 to110. This is the same model used for derivation of the German table DAV-2004R. We refer to the work done there (DAV, 2005) to assess the adequacy of such a model for interpolating mortality for the older age band.

Construction of the 2nd Mortality Improvement Trend

One of the main drivers of focus regarding longevity risk is the quantification of steadily decreasing mortality rates over decades. However, the available insured information is normally not enough to do this and therefore investigations on the decreasing rates, what is commonly called "mortality improvement trend", are usually done on general population mortality. Mortality improvements are commonly defined using a suitable projection trend function $\lambda^G(x)$, which is then applied to the base mortality table. Specifically, for age x, gender G, the one-year (from t to t+1) mortality improvement can be defined as follows:

$$F_t^G(x) := \ln\left(\frac{q_{x,t}^G}{q_{x,t+1}^G}\right) = \ln\left(q_{x,t}^G\right) - \ln\left(q_{x,t+1}^G\right)$$

Using this notation, the k-year projection of the base mortality table is then defined as follows:

$$q_{x,k}^G = q_{x,Base}^G * \exp\left(-k * \lambda^G(x)\right)$$

where the Spanish regulation authority defined the trend function as a weighted average of the yearly mortality improvements observed in the general population between 1976 and 2015

$\lambda^G(x) := \sum_{t=1976}^{2015} w_t * F_t^G(x)$ using the weighting factors

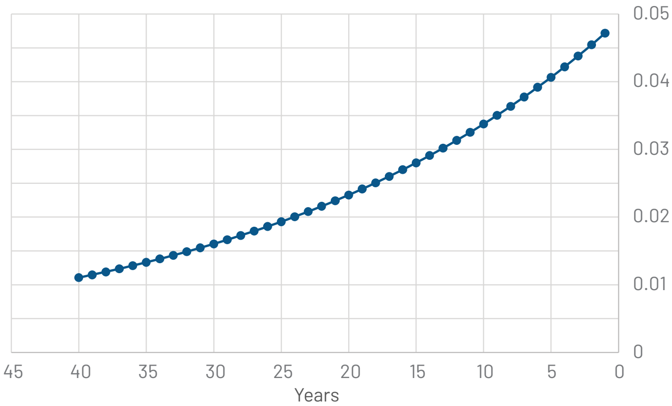
$$w_t := 0.048964 * \exp\left(-0.0372 * (2016 - t)\right)$$

where $\sum_t w_t = 1$

Please note that in the Spanish regulation, the function $\lambda^G(x)$ as described above is first smoothed.[9] For the sake of simplicity, we have omitted this smoothing to avoid occlusion in the notation.

Since mortality improvements have been observed at different rates over time, the idea of using such a weighting function is to give more weight to recent improvements and less importance to the past. The concrete shape of the weight function can be seen in Figure 3.

Figure 3 — Smoothing function for mortality trend function



Source: Gen Re, own elaboration

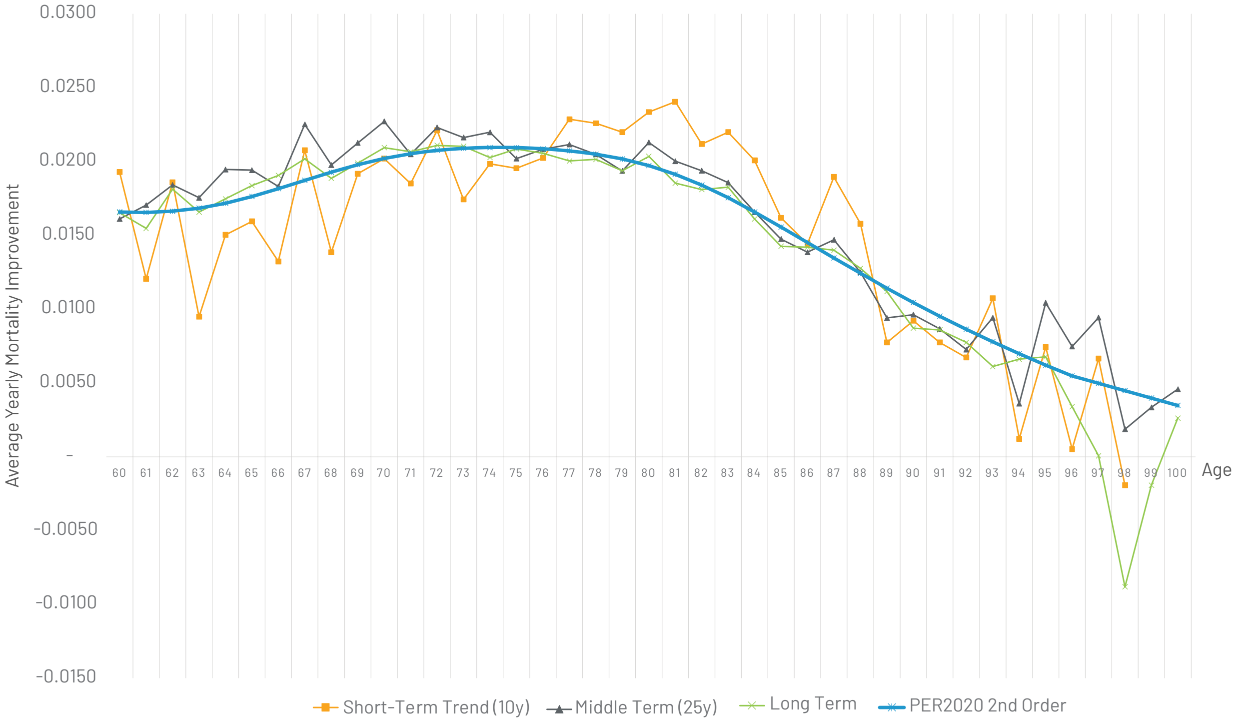
Contextualization of the Weighting Function

As mentioned in the previous section, the Spanish regulation authority used a specific function to weight the mortality improvements in Spain over the last 40 years. Even though the idea behind such a method is clear, it is important to understand the effects of this particular weighting function. To do this, in this section we compare the 2nd Order mortality improvement trend function published with different trends we also derived using general population mortality (HMD. Human Mortality Database, 2024). We consider the following trends in our comparison:

- Short term: Here we estimate the average yearly improvement observed over the last 10 years ending in 2015 (2006-2015)[10]
- Middle term: Here we estimate the average yearly mortality improvements over the last 25 years ending in 2015 (1991-2015)
- Long Term: Here we estimate the yearly mortality improvement over the last 40 years (1975-2015)

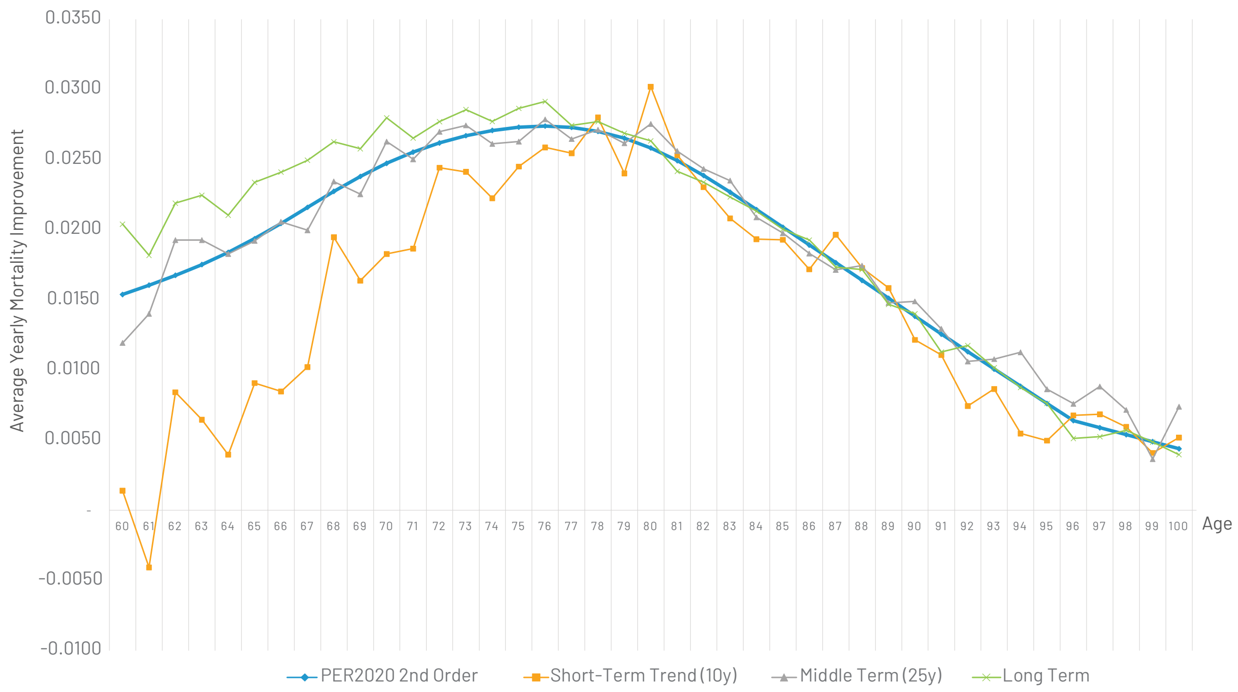
The resulting trends are presented in Figure 4 and Figure 5.

Figure 4 — Comparison of official trend to observed mortality improvements for male



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[11]

Figure 5 — Comparison of official trend to observed mortality improvements for female



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[12]

For males, we can observe that the official 2nd order trend is very close over all ages to the long-term trend. However, the observed middle- and long-term trends are very close to each other. What is remarkable is that the yearly improvement over the last 10 years (short term) has deaccelerated compared to the middle and long term for ages up to 75. In contrast, the average yearly improvements for ages 76 to 88 have been even larger than the middle- and long-term trend. Thus, the official 2nd order trend overestimates the mortality improvements for younger ages up to 75 and underestimates the improvements for ages 76 to 88. For ages beyond 89, the official trend is on average[13] 5% higher than the middle-term trend.

For females, we can observe that the official 2nd order trend follows very closely the mortality improvements over the last 25 years. However, it also becomes clear that the mortality improvements over the last 10 years are significantly lower between ages 60 to 78 than the improvements observed over the last 25 and 40 years. We can clearly see a continuous deacceleration in the improvements for this age range. For ages 79 to 90, all trends are close to each other. Only for ages beyond 90 can we observe a higher improvement between the short- and middle-term trends.

On the one hand, we can state very generally that the recently published 2nd order trend function is very similar to the average mortality improvements observed in Spain for the 25 years prior to 2015.

On the other hand, from a methodological perspective, we can see differences compared to the German actuarial Table DAV 2004R, where they use two trends: short- and middle-term trends. During the projection of cashflows, the short-term trend is used until year T1. Between T1 and T2 there is a linear dampening of this trend to finally reach a certain percentage of the middle-term trend in year T2.

We have two additional comments on these findings in Spain. It is important in future work to better understand if the observed mortality improvements for males between 77 and 88 (which are above the official 2nd order trend) will remain above the official trend or whether it is meaningful to assume some dampening over time. Considering females, the question to ask is if the official 2nd order trend is the right best-estimate for ages 60to 78 since it is much higher than the observed short-term trend.

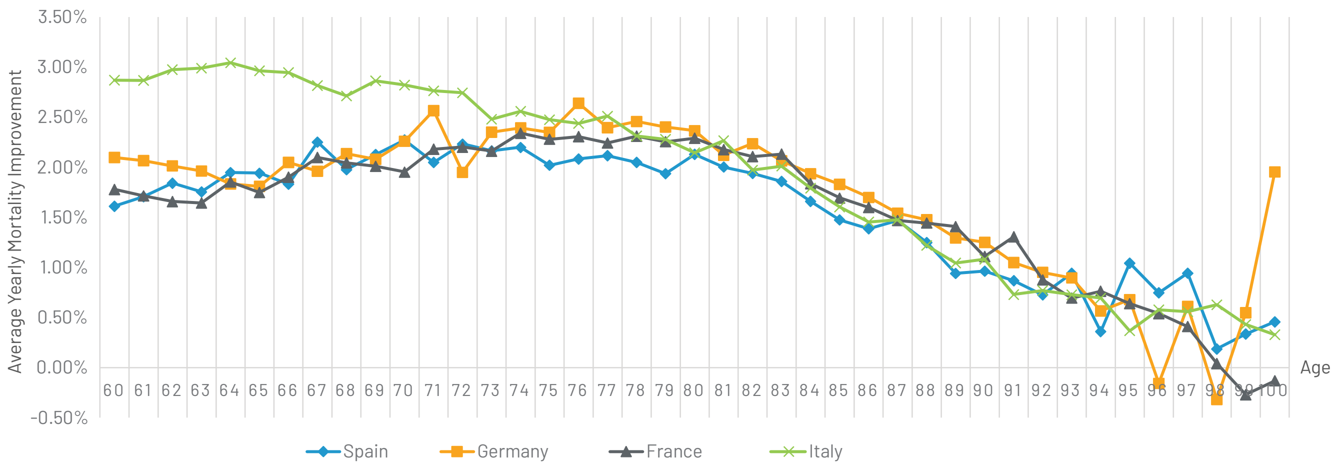
Comparison to Other Countries

A follow-up question is how the mortality improvement in Spain over time compares to other countries. For this purpose, we selected three countries of the European Union to compare with Spain: Germany, France, and Italy. We focused our attention on the middle-term (25 years) trend.

Middle-Term Trend Comparison

For males ages 60 to 72, the middle-term average mortality improvements between Spain, Germany, and France are very similar. The improvements observed in Italy are significantly higher than in the other three countries. For ages beyond 72, the improvement observed in Italy is closer to those observed in the other countries. It is important to note that Spain presents the lowest mortality improvements compared to the rest of the countries (similar to Italy from age 85 and older). This can be seen in Figure 6.

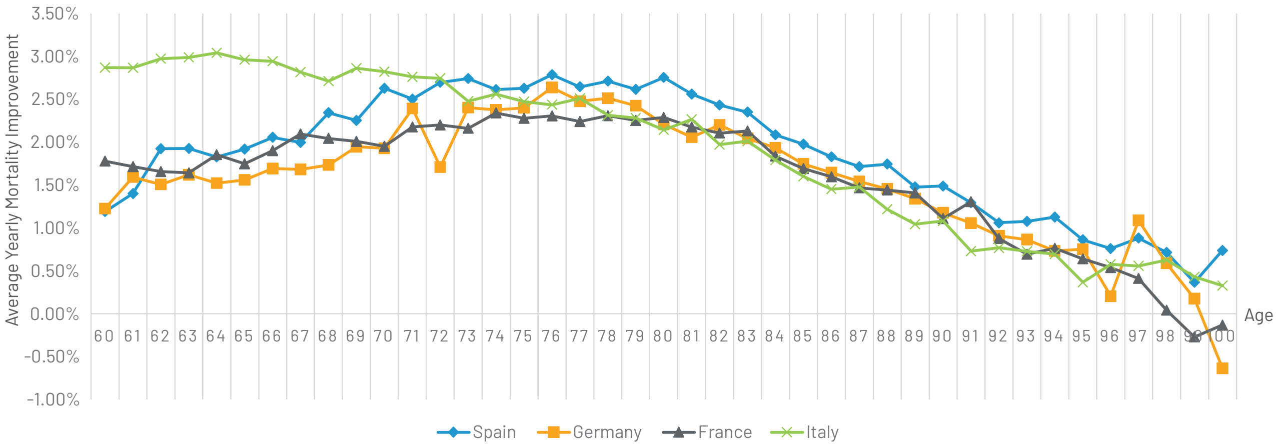
Figure 6 — Comparison of mortality improvement in Spain, Germany, France, and Italy (male)



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[14]

We also observe very high improvements in Italy compared to the other countries for females up to age 71. The differences between Spain, Germany, and France are higher over all ages. However, Spain shows the highest mortality improvement over all other countries and over all ages. This can be seen in Figure 7.

Figure 7 — Comparison of mortality improvement in Spain, Germany, France, and Italy (female)



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[15]

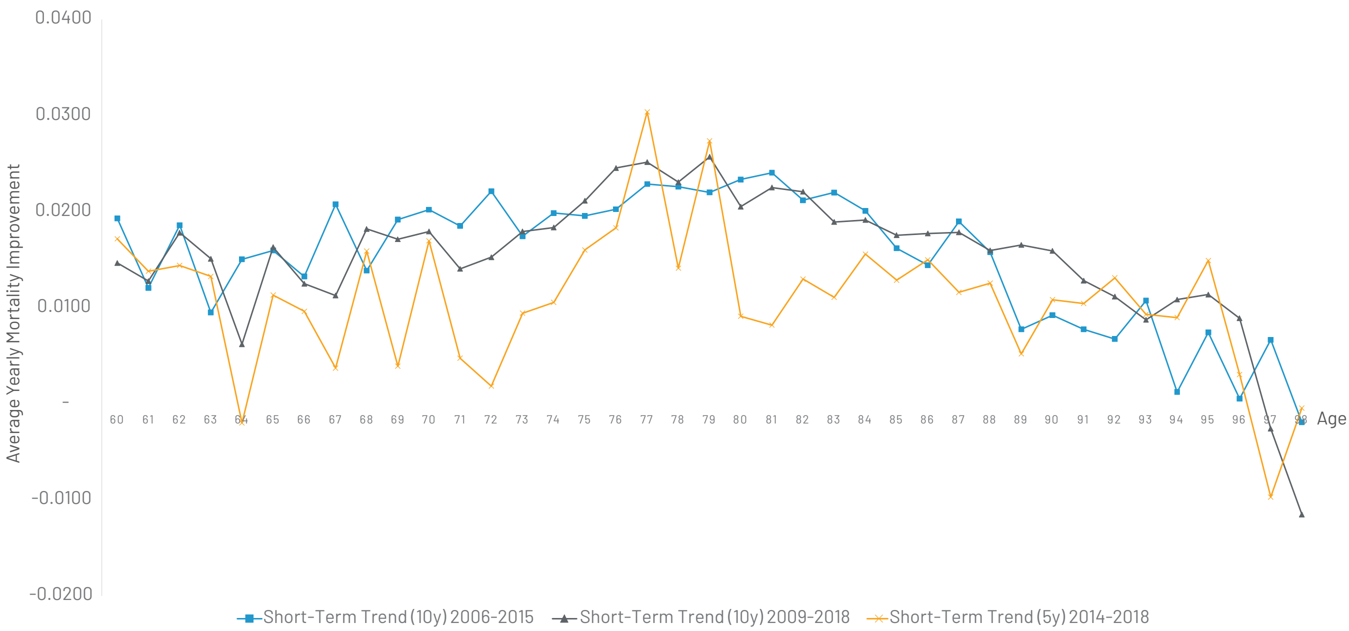
Dampening of Mortality Improvement Trend

One common observation among advanced economies is a possible dampening in the yearly mortality improvement trend observed in the year prior to the COVID-19 crisis.[16] This can also be observed in Spain. To see this, in Figure 8 (male) and Figure 9 (female) we plotted the following average yearly mortality improvements:

- Short-Term Trend (10y) 2006-2015: The average yearly mortality improvement of the 10 years 2006-2015
- Short-Term Trend (10y) 2009-2018: The 10-year average yearly mortality improvement for the years 2009-2018[17]
- Short-Term Trend (5y) 2014-2018: The five-year average yearly mortality improvement for the years 2014-2018

In Figure 8, we can observe lower improvements in the five-year trend than in both 10-year trends (despite a higher volatility).

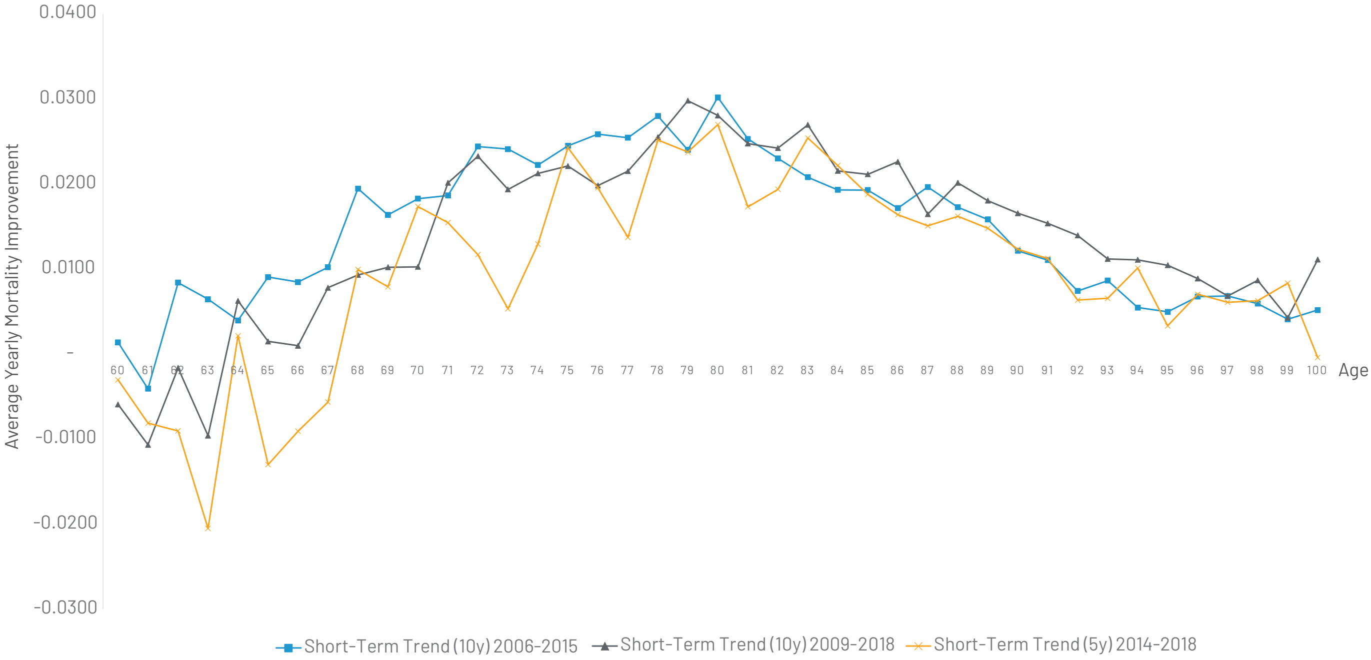
Figure 8 — Mortality improvements (male)



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[18]

This trend dampening is not as clear for female as it is for male. However, we can see it up to age 84. For older ages, we see a similar trend to the 10-year average between 2006-2015.

Figure 9 — Mortality improvements (female)



Source: Gen Re own estimation and visualization for Spain and selected years, based on HMD. Human Mortality Database, 2024[19]

This possible trend dampening observation may inspire actuaries involved in the projection of mortality rates to reflect more deeply about scenarios that consider higher mortality assumptions than assumed by the table PER2020.

Construction of the 1st Order Mortality Assumptions

1st order tables are constructed from the 2nd order tables, adding different security margins. Specifically, three loadings are calculated for the Spanish PER2020 table.

1. Age-dependent loading for volatility risk on the base table

2. Model parameter error loading on the base table

3. Trend deviation risk loading

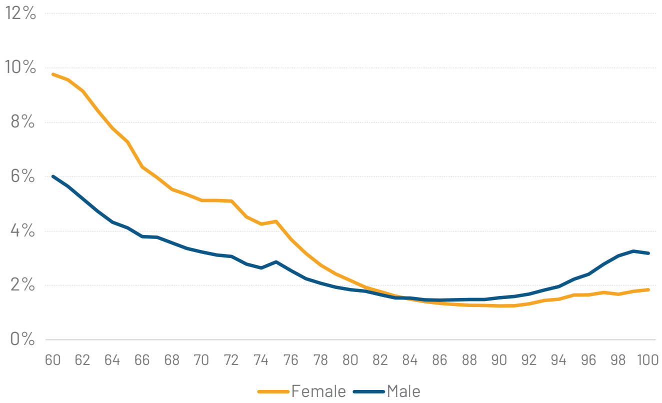
Volatility Risk Loading

In Figure 10 we can see that this charge is different for male and female. Up to age 80, the charge for female is considerably higher than for male. This relationship inverts for ages beyond 80. Also, the gap between both charges decreases with age. This is clear from the construction of the loading:

$$vola_x = \frac{\sqrt{Var(d_x)}}{z_{75\%}/E(d_x)}$$

where the number of deaths d_x is assumed to follow a binomial distribution and thus for large samples it approximates a normal distribution. $z_{75\%}$ is the 75% percentile of a standard normal distribution. The higher the volatility (measured through the standard deviation), the higher the loading.

Figure 10 — Volatility risk loading by age and gender



Source: DGSFP, 2019[20]

Model Parameter Error

A flat 5% charge is applied. It is important to note that the volatility and model parameter error loading are applied together in a multiplicative manner on the base mortality rate.

$$total\ loading_x = 1 - (1 - vola_x)(1 - error)$$

Thereafter, age-smoothing using Whittakker-Henderson is used.

Additionally, and deviating from the above methodology, the insurance regulation authority in Spain regarding volatility and model error decided for lower ages between 60 and 70 to use a constant loading of 9,75% for male and female. Also, for ages up to 97, a constant loading of 7% and 6,5% was used for male and female, respectively.

Comparison Between 1st and 2nd Order Table

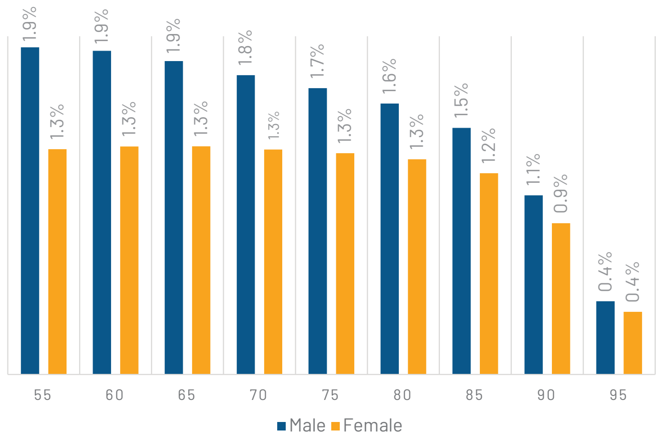
Mortality levels between 2nd order and 1st order tables vary across different ages and due to the used mortality trend, they accumulate over time. To cope with this difficulty, we measured the difference between both tables using projections of an immediate annuity portfolio. Specifically, first we took the same age and gender structure as the portfolio used for derivation of the 2nd order base mortality table. Thereafter, for a given age x and gender G, we measured the margin:

$$margin_x^G = 1 - \frac{\ddot{a}_{x,G}^B}{\ddot{a}_{x,G}^P}$$

where $\ddot{a}_x$ is an immediate annuity. With the subscripts B and P we assumed different mortality assumptions. This margin was accumulated for every age and gender in the portfolio to obtain the final aggregated margin.

In a first step, we used for both B and P the same base mortality (2nd order) and we only changed the underlying mortality improvement trend, where B was set to be the 2nd order and P set to be the 1st order mortality trend function. In this scenario we measured an overall margin of around 1.4%. This is the impact of changing the trend function from 2nd to 1st order, given certain portfolio structure. For male, this margin constantly decreases over different ages. For female, this margin remains more or less constant until age 85 and decreases thereafter. This can be seen in Figure 11.

Figure 11 — Overall margin by age and gender for changing the mortality improvement trend only



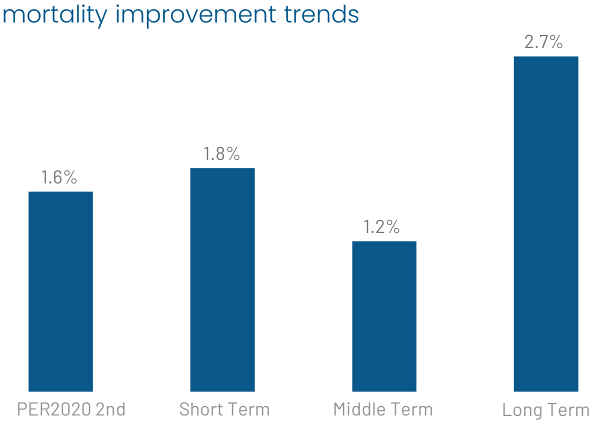
Source: Gen Re, own estimation

In a further step, we changed B to be:

- The observed average middle-term mortality improvement
- The observed average short-term mortality improvement
- The observed average long-term mortality improvement

We can see in Figure 12 that the overall margin of the 2nd order mortality trend is higher than the middle-term but lower than the short-term trend and considerably lower than the long-term trend.

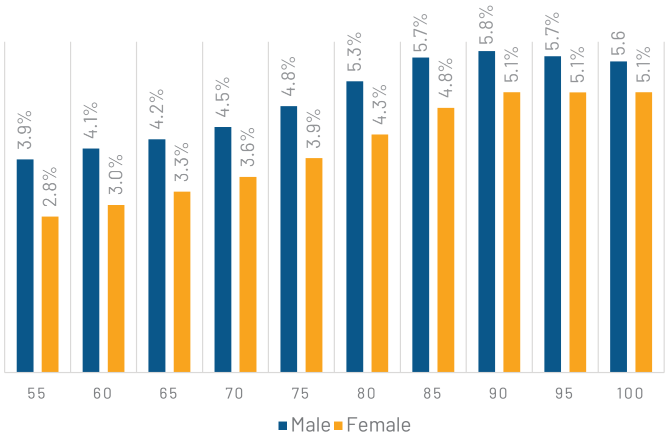
Figure 12 — Overall margin resulting from different mortality improvement trends



Source: Gen Re, own estimation

In a second step, we changed the base mortality table and used for B the 2nd order and for P the 1st order table. We obtained an overall margin of 4.9%. The margin continously increases with age for male and female, reaching more than 5% for older ages, as we can see in Figure 13.

Figure 13 — Overall margin by gender and age between 1st and 2nd Order PER2020 mortality assumptions



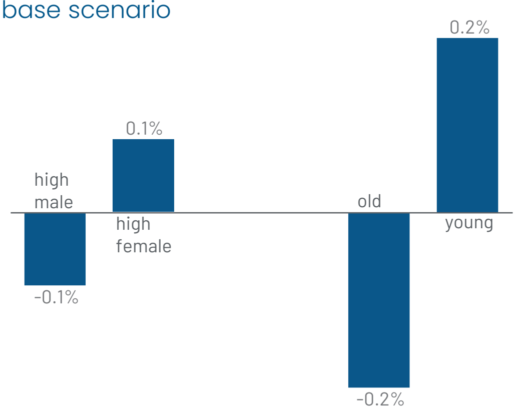
Source: Gen Re, own estimation

We also tested the sensitivities of the overall margin if we changed the underlying biometric structure of the portfolio. For this, we considered four scenarios:

- High male: Here we increased the male proportion by 150% and decreased the female proportion to 75% of the base scenario.
- High female: In this scenario, we increased the female proportion by 150% and reduced to 75% the male proportion.
- Old age: For ages younger than 65, we reduced their proportion to 75% of the original and for ages older than 85 we increased the proportion to 150% of its original proportion.
- Young age: Here we increased the proportion of ages 65 and younger to 150% and reduced the proportion of over 85 to 75% of its original size.

In Figure 14 we can see the change in the overall margin for each of the scenarios compared to the base scenario. Although the impact is not big, we can see negative margins for the second and fourth scenarios.

Figure 14 — Change in margin compared to the base scenario



Source: Gen Re, own estimation

Comparison Between new Table PER2020 and Previous Table

A last question of high relevance to every insurer within the pension market is about the impact they may expect by changing from the old reserving tables to the new PER2020.

We measured this impact using our model portfolio. For this purpose, we set B as the new mortality assumptions PER2020 of 1st order and P as the older mortality assumptions. This resulted in an overall negative margin of -11%, which means there is a considerable financial burden for an annuity portfolio if provisions are made based on the new mortality tables as the insurance regulation authority stipulates for end of 2024.

Conclusion

In this article we described how the new mortality assumptions were constructed and approved by the insurance regulation authority in Spain. We also contextualized these assumptions using observed short-, middle-, and long-term average mortality improvements in Spain. Additionally, we compared the mortality improvements observed in Spain to the mortality development in other European countries and reflected on a possible dampening of the short-term trend in the years prior the COVID-19 pandemic. Finally, we measured the impact of different assumptions within a portfolio of immediate annuities.

We conclude that the trend assumptions assumed by the Spanish insurance regulation authority are adequate if we take as reference the observed mortality development in Spain over the past few decades. In any case, the user should be careful when using the base mortality table for pricing/reserving specifical groups since no selection and socioeconomical factors were considered for the table derivation. This means, that for certain groups, using the table would result in an overestimation of the base mortality, which may represent a risk while pricing/reserving annuity business.

Finally, we acknowledge that the introduced change in mortality assumptions represents a significative financial burden when referred to reserving compared to the old assumptions.

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Endnotes

1 Dirección General de Seguros y Fondos de Pensiones, 2019. Actualización de tablas biométricas. Aspectos revisados., Madrid: DGSFP.

2 Originated by employee´s pension schemes or financial sector obligations (Compromisos por pensiones)

3 Dirección General de Seguros y Fondos de Pensiones, Estuido de impacto, 2019, Tablas Biométricas, https://dgsfp.mineco.gob.es/es/Entidades/EstudiosImpacto/Paginas/EI2019.aspx (Access 15.1.2024)

4 Ibid

5 Ibid

6 Society of Actuaries. Retirement Plans Experience Committee, 2022. RPEC 2022 Mortality Improvement Update, s.l.: SOA

7 Deutsche Aktuarsvereinigung (DAV), 2005. Herleitung der DAV-Sterbetafel 2004 R für Rentenversicherungen, s.l.: s.n, https://aktuar.de/unsere-themen/lebensversicherung/Seiten/sterbetafeln.aspx (Access 1.3.2024)

8 Demographic Censuses. Resident population by date, sex and age (since 1971)., Madrid: s.n.

9 Using Whittaker-Henderson with parameters order=2 and smoothness=0.5

10 We chose 2015 as the ending year in order to compare with the table trend which was derived using 2015 as the last year.

11 HMD. Human Mortality Database, 2024. Human Mortality Database. [Online]
Available at: https://mortality.org/ (Access 10.1.2024)

12 Ibid.

13 Simple average over ages

14 Ibid, see endnote 11

15 Ibid

16 See, for example, "The slowdown in mortality improvement rates 2011-2017: a multi-country analysis", Djeundje et al., European Actuarial Journal. July 2022

17 We have excluded 2019 due to a possible early impact on mortality related to the COVID-19 crisis.

18 Ibid, see endnote 11

19 Ibid

20 Ibid, see endnote 3

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