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Longevity risk transfer: Addressing the misalignment between institutions and individuals

> *"The solution often turns out more beautiful than the puzzle" ~Richard Dawkins*

1. Longevity risk pooling should be widely used… and yet it isn't

In mountaineering, the most difficult part of an ascent is often its descent. The descent is more technical, fatigue-driven, and exposed to weather uncertainty. Retirement finance is similar: both financial and lifespan uncertainties must be overcome during the descent to ensure a soft landing.

Workers who save for retirement using defined contribution (DC) plans or individual retirement accounts (IRAs) are confronted at one point or another with the portfolio decumulation problem—how to draw down their savings after retirement. Simplistic approaches such as the "4% rule"[1] and its many variants are often recommended as a solution to what Nobel laureate William Sharpe once famously called "the nastiest, hardest problem in finance."[2] While better than nothing, such approaches are quite inefficient because they subject people to the risk of outliving their money, which in turn results in the need to spend very conservatively. Efficiently addressing the real problem of lifespan uncertainty requires a different approach.

When individuals decumulate their retirement accounts on their own—even with the help of a financial advisor or Nobel laureate—they do so without the tools necessary to solve the very complex problem of longevity risk management. Going back to the mountaineering analogy, this is like descending an arduous summit on your own… shortly before twilight… without basic equipment.

Commercial lifetime income solutions such as lifetime annuities and defined benefit (DB) pension plans do provide the tooling to handle lifespan uncertainty—longevity risk is transferred from individuals to an institution that pools it, leveraging the law of large numbers to diversify away the risk.

Problem solved? Well, not really, because:

1. Life annuity take-up is extremely low (the infamous "annuity puzzle") despite the clear benefit of risk pooling from a rational economic perspective—simply put, annuities are unpopular.[3]
2. DB plans have been disappearing for years due largely to the substantial costs and risks that they place on the plan sponsor.
3. Insurers are often motivated (whether by regulators or their own risk managers) to limit or ring-fence such risk transfer products to protect themselves from other risks and liabilities.

Many explanations have been given for the annuity puzzle. In this essay, we take a different approach—breaking longevity risk into its primary components to show how the annuity puzzle can be viewed as a fundamental misalignment of the longevity risk transfer between individuals and institutions. Following that, we will discuss what can be done to improve the alignment.

2. Decomposing longevity risk

Longevity risk consists of two primary components: idiosyncratic risk and systemic risk.

Idiosyncratic longevity risk relates to the uncertainty of how much longer any given individual might live. It could be one day, forty years, or any time span in between… or even longer. This risk assessment is made using mortality rate estimates developed by actuaries. Conveniently, idiosyncratic risk is readily diversifiable.

But what if the mortality estimates turn out to be materially incorrect? This is where systemic risk comes into play.

Systemic longevity risk (what actuaries call "aggregate" or "trend" risk) relates to the uncertainty underlying the mortality estimates. Even though actuaries may account for expected improvements in future life expectancy, they may overestimate or underestimate it. Inconveniently, systemic risk is not diversifiable.

For the analysis that follows, we use a mortality table reflecting retirement plan participants who are healthy at the point of retirement. For specifics on this and other assumptions, refer to the section Modeling Conventions.

3. Idiosyncratic risk: The individual lifespan. Difficult to hedge alone, but easy for institutions to mutualize

As we will show, it is quite intuitive to see that idiosyncratic longevity risk is A) the component that individuals are the most exposed to and B) the one that institutions can readily mutualize. This mutualization is the essence of the institution of insurance—using the law of large numbers to pool people together and diversify their risks to the point where almost no (idiosyncratic) risk remains.

3.1. Residual lifetime… the big uncertainty for individuals

The figures below show the distribution of residual lifetime of males and females of various ages under the assumed mortality rates. For example, a 65-year-old male has a 50% chance to reach age 87.6, but also a 25% chance to reach age 92.6 and a 5% chance to reach age 98.6. A 65-year-old female has a 50% chance to reach age 90.3, but also a 25% chance to reach age 95.2 and a 5% chance to reach age 101.

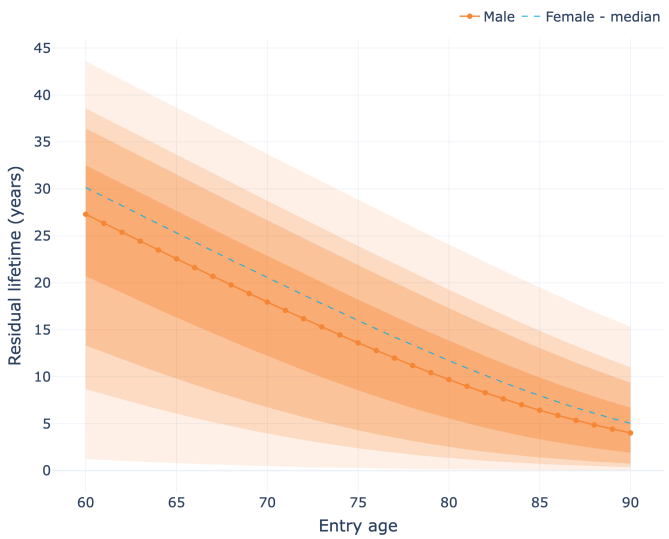


Chart 1 - Residual lifetime of a single life - Male - median, 25-75, 10-90, 5-95, and 0.5-99.5 percentile bands

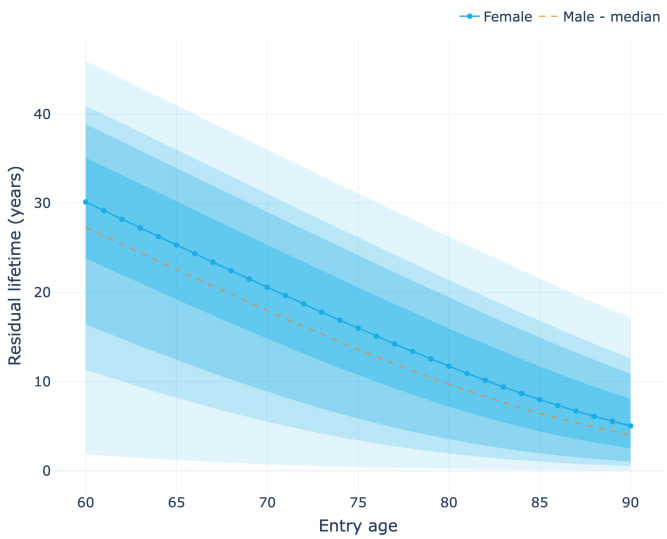


Chart 2 - Residual lifetime of a single life - Female - median, 25-75, 10-90, 5-95, and 0.5-99.5 percentile bands

Entry age	p5	p10	p25	p50	p75	p90	p95
60	8.7	13.3	20.7	27.3	32.5	36.4	38.6
65	6.1	9.8	16.3	22.6	27.6	31.5	33.6
70	4.0	6.8	12.2	18.0	22.8	26.7	28.7
75	2.4	4.3	8.6	13.6	18.2	21.9	23.9
80	1.3	2.5	5.6	9.7	13.8	17.3	19.3
85	0.7	1.4	3.3	6.4	9.9	13.0	14.9
90	0.4	0.8	1.9	4.0	6.7	9.4	11.0

Table 1 - Residual lifetime by entry age - Male, in years

Entry age	p5	p10	p25	p50	p75	p90	p95
60	11.3	16.4	23.8	30.1	35.1	38.9	40.9
65	8.2	12.4	19.2	25.3	30.2	33.9	36.0
70	5.5	8.9	14.8	20.6	25.3	29.0	31.0
75	3.4	5.9	10.7	16.0	20.5	24.2	26.2
80	1.9	3.5	7.2	11.7	15.9	19.4	21.4
85	1.0	2.0	4.4	8.0	11.7	14.9	16.8
90	0.5	1.0	2.5	5.0	8.0	10.9	12.6

Table 2 - Residual lifetime by entry age - Female, in years

Because it is risky to plan to live only to one's life expectancy (after all, 50% is a coin flip), financial planners typically recommend planning for the possibility of living well beyond the median. Naturally, this materially increases the cost of retirement financing for those who decumulate their retirement assets on their own without the benefit of longevity risk pooling, because each dollar of savings must be stretched to last longer.

Extending the planning horizon results in reduced retirement income each year as shown in Tables 3 and 4. For example, a 65-year-old male who plans to the 95th percentile of lifetime (i.e., 33.6 years in retirement, to age 98.6) would require approximately 25% more in savings to support each dollar of planned monthly spending than if he had planned to live only to the median (i.e., to age 87.6). This additional amount can be thought of as a self-financed *longevity reserve*. Equivalently, his monthly income must be cut by approximately 20%.[4] And remember: under this plan he still bears the residual 5% of longevity tail risk, along with a significant probability (50%) that he won't live long enough to ever see any benefit from his conservative planning. So, even though his plan may seem prudent, it is far—indeed, very far—from efficient.

	p50	p75	p90	p95
Planning horizon	22.6	27.6	31.5	33.6
Longevity reserve	0.0%	12.1%	21.0%	25.5%
Spending cut	0.0%	-10.8%	-17.4%	-20.3%

Table 3 - Spending reduction at various planning horizons - age 65 - Male

	p50	p75	p90	p95
Planning horizon	25.3	30.2	33.9	36.0
Longevity reserve	0.0%	9.5%	16.1%	19.5%
Spending cut	0.0%	-8.6%	-13.9%	-16.3%

Table 4 - Spending reduction at various planning horizons - age 65 - Female

3.2. Risk pooling resolves this big uncertainty… and for a large enough group, it almost disappears

This idiosyncratic risk can be diversified quite easily by pooling individual retirees together. The pooling effect works fast, as revealed in the charts and tables below. The figures reflect simulated valuations of an annuity portfolio pool of similar contracts for the age-65 cohort. The valuations are expressed as an *annuity factor*: the cost today of 1 unit of monthly lifetime income. They illustrate the probability distribution of these valuations for pools of different sizes.[5]

By pooling multiple lives together, the probability distribution narrows significantly as the law of large numbers kicks in. With as few as 50 lives, the idiosyncratic risk has already dropped sharply. For a pool of 10,000 lives, it is negligible. Measured at the 99.5th percentile, the deviation from the median is only 0.40% for males and 0.42% for females—dramatically lower than the idiosyncratic risk borne by an individual who does not pool longevity risk, for whom the deviation from the median is 32.22% for males and 26.71% for females.

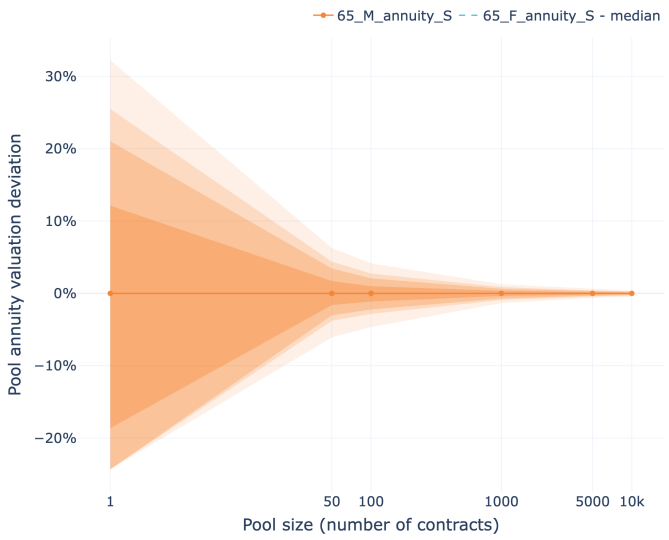


Chart 3 - Pooling effect - Male - Annuity factor deviation under mortality simulation of a portfolio of identical contracts

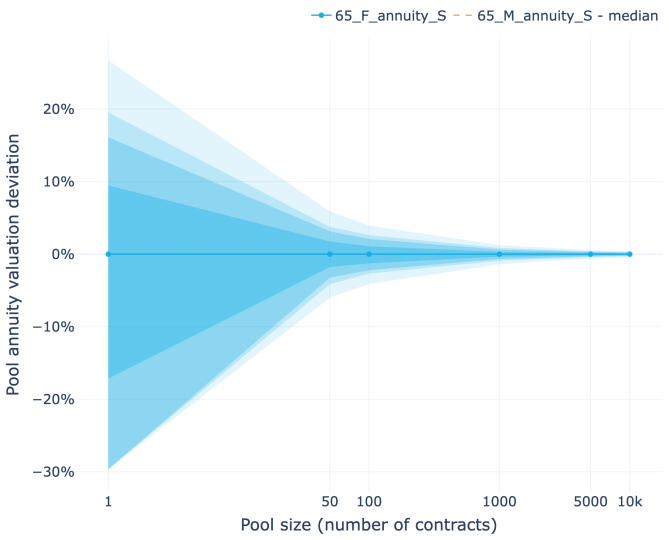


Chart 4 - Pooling effect - Female - Annuity factor deviation under mortality simulation of a portfolio of identical contracts

Portfolio size	p75	p90	p95	p99.5
1	12.1%	21.0%	25.5%	32.2%
50	1.7%	3.4%	4.4%	6.3%
100	1.0%	2.1%	2.7%	4.1%
1000	0.4%	0.6%	0.9%	1.3%
5000	0.2%	0.3%	0.4%	0.6%
10000	0.1%	0.2%	0.3%	0.4%

Table 5 - Annuity factor deviation under mortality simulation of a portfolio of identical contracts - Male

Portfolio size	p75	p90	p95	p99.5
1	9.5%	16.1%	19.5%	26.7%
50	1.7%	3.2%	3.8%	5.9%
100	1.1%	2.1%	2.6%	3.9%
1000	0.3%	0.6%	0.8%	1.2%
5000	0.2%	0.3%	0.4%	0.6%
10000	0.1%	0.2%	0.3%	0.4%

Table 6 - Annuity factor deviation under mortality simulation of a portfolio of identical contracts - Female

4. Systemic risk: the overall longevity trend. An inconvenience for individuals, but a bomb for institutions

Systemic longevity risk is linked to mis-estimating the trend of future mortality rates. The quantification of this risk is notoriously difficult and is the subject of many discussions and differences of opinion. To avoid arguments by choosing a method of our own, we look instead to existing regulation as a guide—in this case, the European Union's Solvency II regulation.[6]

Solvency II prescribes a 20% drop in mortality as the basis shock to apply for the longevity risk module. This 20% value is calibrated to represent a 99.5% probability level of covering the risk.[7] Because some studies estimate the magnitude of systemic longevity risk to differ widely, we consider the impact of both a 10% and a 20% drop in mortality.

Tables 7 and 8 show the effect of the systemic risk for the age-65 cohort. Table 7 shows how much the systemic risk reserve increases the valuation of an annuity's cost. Naturally, this increase in cost reduces the annuity's payout rate, as shown in Table 8. The row labeled "perfect estimate" refers to the valuation without any consideration of systemic risk (i.e., as if there were no mis-estimation risk whatsoever). The "variation (%)" column measures the increase in the annuity cost (or the decrease in the annuity payout) due to a given level of systemic risk.

	Male	Male	Female	Female
Scheme	annuity factor	variation (%)	annuity factor	variation (%)
perfect estimate	177.1	0.0%	187.0	0.0%
mortality -10%	180.0	1.7%	189.9	1.5%
mortality -20%	183.4	3.6%	193.2	3.3%

Table 7 - Annuity factor (monthly) and its variation against the perfect estimate, by mortality scheme and sex

	Male	Male	Female	Female
Scheme	payout (for 100k)	variation (%)	payout (for 100k)	variation (%)
perfect estimate	564.7	0.0%	534.6	0.0%
mortality -10%	555.4	-1.6%	526.5	-1.5%
mortality -20%	545.3	-3.4%	517.7	-3.2%

Table 8 - Payout (monthly, for 100k) and its variation against the perfect estimate, by mortality scheme and sex

Why is the systemic risk a much bigger deal for institutions than it is for individuals? Because institutions face the risk of bankruptcy if they underestimate the risk. This risk is not as big a deal for individuals, however, as we show in the next section.

5. In summary: there is a fundamental dichotomy in longevity risk—and it is a very different story for individuals and institutions

Below is a summary of the longevity risk shocks applied to the present value of a lifetime income stream for 65-year-old males.

Risk	Level	Individual (65 M)	Institution (10,000 contracts)
Idiosyncratic	99.5th percentile	**32.2%**	0.4%
Idiosyncratic	90th percentile	**21.0%**	0.2%
Systemic	20% drop in mortality	3.6%	**3.6%**
Systemic	10% drop in mortality	1.7%	**1.7%**

Table 9 - Idiosyncratic and systemic longevity risk shocks on the value of a lifetime income stream - Individual (65 M) vs. Institution (10,000 contracts)

For individuals, their own lifespan—idiosyncratic risk—is very high, while the overall longevity trend impact—systemic risk—is far smaller. For institutions, this relationship is exactly reversed in that the idiosyncratic risk is extremely low, while the systemic risk is much greater.

For institutions, the longevity trend risk represents a significant part of their regulatory solvency requirements. Solvency margin assets are expensive to hold, and both immediate and deferred lifetime annuities are highly cost-sensitive to this. To give an order of magnitude, for a life annuity portfolio with a 6% capital requirement on its technical reserves and an 8% economic cost of capital, this represents an additional 48 basis points of the technical reserves per year as margin loadings just to maintain shareholders' remuneration. If we assume from the above numbers that the longevity trend represents a meaningful portion—say, one-third—of this capital cost, we reach approximately 16 basis points annually just to cover the systemic longevity risk. In terms of the final annuity cost, this represents around a 1% to 2% increase in the price.[8]

Put simply: to insure the trend risk, the retiree pays an extra 1–2% of the annuity price, *every time and for certain*. In return, they are protected against a shortfall that is zero if the mortality estimate is right, about 1.7% of assets if mortality falls 10% below expectations, and about 3.6% in the 1-in-200 scenario that Solvency II uses. For every 100,000, a 65-year-old man receives about 565 a month under the perfect estimate, against 555 if the insurer reserves for a 10% drop in mortality and 545 for a 20% drop (Table 8). By contrast, the lifespan risk that pooling removes is worth 20–30% of income. Pooling is where the value is; insuring the trend is a comparatively expensive add-on. An individual is therefore likely to be better off pooling the idiosyncratic risk and retaining the systemic risk. The same holds for women (Tables 7 and 8). Moreover, if an individual's idiosyncratic risk has been pooled in a longevity risk *sharing* arrangement, then an unexpected increase in population longevity need not bankrupt the

individual as it would an institution. Instead, it would lead to a gradually reduced income stream—which is certainly better than suddenly running out of money. This does not hold for everyone: retirees with no spending flexibility, or for whom this is their only income, may rationally pay for certainty.

> *It is ironic (and tragic, in a way) that, structurally, the longevity trend risk that is expensive to cover for institutions is the one that individuals can bear without too much adversity.*

6. Conclusion: What does this mean for the future of longevity risk transfer?

Longevity risk pooling will become a cornerstone of the retirement offer in the coming years. With an ageing population and the decline of DB plans, it is difficult to justify a retirement strategy that does not include at least some allocation to assets that provide lifetime income.

But the path to longevity risk pooling will be difficult if the longevity risks of the institutions providing it are not well aligned with those of their customers. This is a real problem for guaranteed annuities and DB plans. Not only is the institutional cost of reserving against lifetime annuity guarantees and DB liabilities expensive, but the capital requirements of doing so also raise questions of capacity in a capital-constrained world.

> *To be efficient, longevity risk transfer should prioritize solutions that allow individuals to retain systemic longevity trend risk while diversifying away individual lifespan risk.*

Fortunately, an institutional solution that aligns much better with the longevity risk exposure of retirees does exist—longevity risk *sharing* pools, sometimes called modern tontines, pooled annuity funds, variable payout life annuities (VPLAs), or group self-annuitization pools. Designed correctly, a longevity risk sharing pool can diversify substantially all of the idiosyncratic longevity risk, while leaving the systemic risk for the pool participants to share. In such a pool, income is recalculated periodically against actual survival. If mortality turns out 20% lower than expected—the Solvency II 1-in-200 scenario—payouts fall by 3.4% (Table 8), and this adjustment is spread over the years rather than imposed at once. Because it requires no solvency capital for longevity risk, such a pool can be offered at a fraction of the cost of a life annuity, leaving only administration and governance costs.

7. Assumptions and Sources

7.1. Modeling Conventions

Mortality rates

Our modeling used the “Canadian Pensioner Mortality 2024” (CPM2024) mortality tables. More specifically, we used the amounts-weighted “combined retiree” mortality tables for both males and females. The ultimate age of these tables is 120. To compute life expectancies and annuity factors, we use standard actuarial techniques to interpolate the annual mortality rates given in the CPM2024 to create daily mor-

tality rates to more accurately reflect the survival probabilities of persons who are born on any given birthdate. The tables are used statically: no future mortality improvement scale is applied, so the -10% and -20% shocks below can be read as unanticipated improvements.

Annuity factors

Monthly annuity factors are computed for a variety of life annuity purchasers using a fixed 4% nominal assumed annual interest rate. The purchasers in our analysis range in age from 60 to 90. Those who are younger than 85 at the time of purchase may elect to receive "certain period" payouts that run to the later of 1) the annuitant's death or 2) a selected number of months. For brevity, we choose to focus primarily on the age-65 cohort, both male and female. All results shown use a life annuity with a 15-year certain period purchased at age 65.

Simulation

To simulate stochastic idiosyncratic longevity risk, we ran a Monte Carlo simulation of 20,000 possible outcomes for each selected cohort. Simulations use the mortality table to draw random dates of death for each annuitant, and we built "pooled portfolios" of 1, 50, 100, 1,000, 5,000, and 10,000 persons by resampling these individual outcomes, measuring outcomes at selected percentiles.

We do not simulate systemic longevity risk stochastically in this analysis (although we have done so in other studies, with similar results). Instead, we select "mortality shocks" of -10% and -20%, in which the CPM2024 mortality rates are reduced by 10% and 20%, respectively. Our choice of a -20% mortality shock is informed by its use in the Solvency II regulation that governs annuity providers in the European Union and other jurisdictions. Our choice of a -10% mortality shock is meant to serve as a less conservative estimate of the mortality trend risk than that required in Solvency II. The systemic results are deterministic valuations under each mortality scheme; since the idiosyncratic risk of a 10,000-life pool is negligible, they apply equally to the individual and the pool (Table 9).

Fees and other considerations

Because our study is only meant to quantify and compare the components of longevity risk, our analysis does not include any additional fees that may be embedded within life annuity products for other reasons, such as profit margins. Because this analysis is meant to isolate longevity risk due to mortality uncertainty, investment risks such as interest rate and credit risk are not considered.

7.2. About the authors

Pascal Winter, Nuovalo Ltd.

Richard K. Fullmer, Nuovalo Ltd.

Nuovalo is a global fintech company that conducts independent pension research and offers consulting and technology services in the field of efficient lifetime income solutions, including longevity risk sharing pools.

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1. See Bengen (1994) – "Determining Withdrawal Rates Using Historical Data".↵
2. Bloomberg – "Tackling the 'Nastiest, Hardest Problem in Finance'".↵
3. See, for example: Hershfield, H. E., Shu, S., Brown, J. R., Hurwitz, A., Milevsky, M. A., Mitchell, O. S., & Toland, T. (2026) – "The Annuity Puzzle Revisited: Barriers, Behavior, and Policy Paths to Lifetime Income".↵
4. The longevity reserve is computed as the excess of the present value of an annuity stream that runs to the planning horizon rather than only to the median life expectancy. The spending reduction is then computed as: 1/(1 + *longevity reserve*) – 1.↵
5. Specifically, we measure this as the deviation in the annuity portfolio valuation at given percentiles relative to the median. Readers may notice that the values in the first row of Tables 5 and 6 for a portfolio size of 1 are the same as the corresponding entries in the "Longevity reserve" row of Tables 3 and 4. This is because in this case the individual essentially *self-insures* and thus personally bears all of the idiosyncratic risk.↵
6. See Directive 2009/138/EC S2: COMMISSION DELEGATED REGULATION (EU) 2015/35 - Section 3 - Article 138.↵
7. To be precise, Value at Risk (VaR) at 99.5% over one year.↵
8. The capital charge is paid every year on the outstanding reserve. For a 65-year-old male at 4%, the sum of discounted future reserves is about 10 times the initial premium, so 16 basis points a year amount to about 1.6% of the purchase price.↵