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Portfolio perspectives

On track for success? Insights from stochastic health care modeling

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- Common financial planning practice is to minimize, at almost any cost, the risk of early depletion of a retirement portfolio by assuming a lengthy, fixed life expectancy. This conservative approach can imply an unrealistically low probability that a portfolio will sustain a retiree and potentially suggest unnecessary spending cuts and a reduction in standard of living. We show how using longevity estimates that are stochastic—that is, incorporating uncertainty—and more personalized can provide better insights into a retirement plan's probability of success. In this context, we examine how longevity interacts with health status and the potentially large retiree expenses that can occur.

- We provide insight into how changes in health care status can affect health care spending in retirement. We find that using simple deterministic estimates of health care costs—that is, estimates that are fixed over time—provides sufficient insight into a plan's viability. Nevertheless, this kind of estimate obscures the challenges to a fixed spending strategy amid uncertain and highly variable health care needs.

- Just as most investors and advisors now assess the viability of their retirement plans using simulations that reflect asset return uncertainty, stochastic modeling of longevity and recurring health care costs will increasingly become essential tools in the advisory toolkit. As researchers and advisors develop these capabilities, investors will benefit from more customized financial plans to navigate an uncertain and dynamic retirement.

Today, investors and advisors use stochastic forecasts of asset class returns to evaluate the sustainability of retirement spending strategies. The shift from deterministic to stochastic forecasts, which gathered pace in the late 1990s (Quinn, 1999), has yielded simple but profound insights. When asset class returns vary from year to year, a portfolio that returns, on average, 6% annually may not be able to sustain annual spending of 6% over long horizons. Deterministic forecasts obscure this reality.

Retirees face other sources of uncertainty. Chief among them are their health and the associated costs. As with asset class returns, this uncertainty can have a big effect on a retirement plan's viability.

In our analysis, we estimate the probability that a 65-year-old female investor will transition from one health state in retirement to another. We then estimate how these transitions will affect a retiree's life expectancy and out-of-pocket health care costs. Compared with planning approaches that assume a fixed life expectancy (age 100, for example) and that use deterministic health care costs, a stochastic health care model gives investors and advisors more realistic insights into how longevity and health care-related risks affect the viability of spending plans in retirement.

Research design

Ever since Bengen's seminal 1994 paper on sustainable withdrawal rates in retirement, the field of financial and retirement planning has gradually replaced a linear deterministic assumption of average returns with a stochastic view. Over the past 27 years, it has become common in retirement planning to develop stochastic models of asset class returns and use them to estimate portfolio success rates, or the likelihood that a portfolio will be depleted.

Retirees face other uncertainties that can affect their retirement outcomes (Jaconetti et al., 2021). The two most notable are retirees' future health states and the related risk of large, unexpected changes in health care costs.[1]

We use four quantitative frameworks to evaluate the viability of a common spending strategy under different assumptions about longevity risk and health care costs (**Figure 1**). To tease out the implications of longevity and health care cost risks from asset return risks in calculating the portfolio success rates, we use a thousand simulated paths for future asset class returns based on the Vanguard Capital Markets Model® (VCMM) for all four frameworks (Davis et al., 2014).

Figure 1. The four frameworks rely on different assumptions of longevity and health care costs

Framework	Longevity	Health care costs
1	Live to age 100	Deterministic health care costs
2	Social Security Administration mortality table	Deterministic health care costs
3	Demographic-based mortality rates*	Deterministic health care costs
4	Demographic-based mortality rates*	Demographic-based stochastic health care costs

* The demographic group classification is based on gender (female or male, in line with the Health and Retirement Study and Social Security Administration definitions), relationship status (single or couple), income (five quintile groups), and initial health state (good, fair, light long-term care, severe long-term care).

Notes: The distribution of asset returns is sourced from the Vanguard Capital Markets Model (VCMM) and is a forecast of stochastic equity and bond returns. We ignore initial market conditions in this analysis and therefore use the long-term steady state market component. For this reason, the results should not be interpreted as a recommendation for current market conditions.

Source: Vanguard calculations, based on data from the Social Security Administration and the Health and Retirement Study.

IMPORTANT: The projections and other information generated by the VCMM regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Distribution of return outcomes from the VCMM are derived from 10,000 simulations for each modeled asset class. VCMM simulations represent a steady state forecast derived from simulations as of March 2019. Results from the model may vary with each use and over time. For more information, see the Appendix section "About the Vanguard Capital Markets Model."

1 We classify health state into five groups: 1) good (self-reported health being good, very good, or excellent, and no help needed for daily activities); 2) poor (self-reported health being poor or fair, and no help needed for daily activities); 3) light long-term-care (LTC) need (help needed for one to two daily activities); 4) severe LTC need (help needed for 3+ daily activities); and 5) death.

The first framework is the simplest. We assume a fixed life expectancy, to age 100, for all investors and model health care costs as fixed over time. The only risk, therefore, is the uncertainty of markets.

In the second framework, we replace the fixed life expectancy with gender-specific Social Security Administration (SSA) mortality tables, which estimate changes in life expectancy as people age. Here, the individual is no longer planning on the basis of a specific time horizon. Instead, that person is in a more uncertain situation in which he or she could pass away earlier or later than the life expectancy.

In the final two frameworks, we incorporate additional insights into longevity risk and health care cost uncertainty. We develop a health state transition model that estimates the likelihood that different demographic groups will transition from one health state to another (from good to fair, for example) and this health state transition's impact on mortality rates.[2] We estimate the health state transition probabilities with a multinomial-logit regression model calibrated to a nationally representative sample of American retirees in the Health and Retirement Study. The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

To calculate the retirement portfolio's success rate, in the final two frameworks, we incorporate 1,000 simulated life paths of health states (including mortality) based on individuals' initial demographic characteristics and health conditions. This means that the final two frameworks further personalize the distribution of potential longevity outcomes according to the investor's demographics and initial health.

Across the four frameworks, we use two different assumptions about health care costs. The first three frameworks assume a fixed health care cost for all investors over the retirement period. The final framework assumes that retirees' health care costs are uncertain because of uncertain, changing health states over the retirement period. Retirees with the same demographic characteristics and health states are assumed to have the same health care costs. But health care costs can vary by age as well as health state. We simulate 1,000 life paths of health care costs based on projected health state at each age and an estimated average out-of-pocket cost for the corresponding health state based on age group, gender, and relationship status using the same HRS data sample.

2 We model the health state transition to follow a five-state Markov chain process. We base the health state transition probabilities on age, gender, relationship status, income, and current health state.

In the following sections, we conduct a portfolio success rate exercise to evaluate the viability of a 6% fixed dollar retirement-account withdrawal rate under different frameworks. (Six percent was chosen to illustrate the sensitivity of the models and does not represent a recommendation for a sustainable spending strategy.) Success rate is a widely used but limited measure. It provides useful insight into the probability that a retiree will deplete his or her portfolio, but little insight into how health care shocks can affect income stability in retirement.

For ease of discussion, we present the results for a 65-year-old female (**Figure 2**). In the Appendix, we include the results for male retirees with various demographic characteristics modeled in our simulation (**Figure A-1**).

Figure 2. Factors used in evaluating a 6% fixed dollar withdrawal strategy

Investor profile	
Gender	Female
Relationship status*	Single or couple
Starting age	65
Initial health state	Good, fair, light LTC, or severe LTC
Starting balance	$500,000
Target living cost**	$47,000 per annum (in real, or inflation-adjusted, terms)
Deterministic health care cost***	$3,000 p.a. (in real terms)
Government payments	$20,000 p.a. (in real terms)
Asset allocation	50% U.S. equities and 50% U.S. bonds

* Relationship status is used to adjust longevity forecasts and health care expenses. In these cases, we assume that the individual remains single or remains in a couple in all scenarios for the full retirement.

** This excludes any out-of-pocket health care costs.

*** We assume the retiree is eligible for the basic Medicare program but not Medicaid. The annual deterministic health care cost is based on the average estimate of total out-of-pocket expenses for a sample of retirees in the HRS who were over 65 and not enrolled in the Medicaid program during 2010 and 2018. The cost measure includes prescription drug costs and costs for hospitalization, nursing home care, doctor visits, dental visits, and outpatient care (insurance premiums excluded). For a more practical estimate of the health care costs, please see Bailey et al. (2021).

Source: Vanguard.

Importance of mortality tables for success rate analysis

We first compare the success rates of the 6% withdrawal strategy under the first three frameworks across 16 demographic groups. The key difference among the models is our assumption about longevity risk.

The first framework assumes without any uncertainty that the investor lives to age 100—a highly conservative assumption typical of retirement planning approaches that seek to minimize the risk of portfolio depletion at almost any cost. The second framework uses the SSA's gender-dependent mortality tables. The third framework uses the demographic-dependent mortality rates estimated from the health state transition model.

Figure 3 shows the implied success rate and life expectancy for different types of 65-year-old female retiree investors under Frameworks 1, 2, and 3.

Under the first framework, without longevity risk, there is about a 1 in 3 chance that a single retiree will meet her retirement spending target until she reaches age 100. Again, this longevity assumption is highly conservative in financial terms. For those who are age 65 today, a man has a 2.6% chance and a woman a 5.6% chance of living to age 100.[3]

The second framework, which includes a gender-dependent mortality rate using the SSA mortality table, suggests a 71.3% success rate for the same strategy for this female investor.[4] The main reason for a 37.7 percentage-point increase in success rates is that the first framework overstates longevity risk for a retired investor, though it also captures the more than 4% chance that the female lives beyond 100.

The significant contrast between the first framework and the next two frameworks suggests that, to obtain the most realistic representation of a retiree's future, it is crucial to use population-based mortality tables in assessing a portfolio's viability. The use of a conservative, fixed horizon can imply an unrealistically low probability of success, suggesting the need for spending cuts that diminish a retiree's standard of living.

Comparing Frameworks 2 and 3, we find the frame-work with a simple gender-dependent mortality table overestimates the life expectancy and therefore underestimates the success rates of the same spending strategy for investors with relatively poorer health states and for single retirees (and vice versa for investors in good health states and for retired couples).

A richer framework that takes into account demographic-dependent uncertain health states during retirement reveals the variability of life expectancy and success rates across different demographic groups.

Figure 3. Personalized longevity estimates in Framework 3 offer more realistic assessment of the viability of spending plans than fixed life expectancy or gender-specific mortality tables

a. Single female

	Initial health state	Success rate	Average life expectancy
Framework 1	All health states	33.60%	100
Framework 2	All health states	71.30%	86.8
Framework 3	Good	70.10%	87.4
	Fair	74.40	85.2
	Light LTC	78.80	82.8
	Severe LTC	85.50	78.8

b. Female in a couple

	Initial health state	Success rate	Average life expectancy
Framework 1	All health states	33.60%	100
Framework 2	All health states	71.30%	86.8
Framework 3	Good	63.80%	89.6
	Fair	67.70	87.8
	Light LTC	72.20	85.5
	Severe LTC	80.30	81.0

Source: Vanguard calculations, based on data from VCMM, the Social Security Administration, and the Health and Retirement Study.

3 The projected mortality experience is computed based on the SSA projected cohort life tables for the 1956 cohort.
4 The forecasts of life expectancy at age 65 in 2021 based on the SSA mortality tables are 87 for females and 85 for males.

Stochastic modeling of health care costs highlights stability of spending

In this section, we compare the simulation results for the final two frameworks across 16 demographic groups.

We present the simulated life expectancy, success rate, and average annual health care cost (out-of-pocket excluding insurance premiums) for each type of female retiree in **Figure 4**. As the health state changes, we see the expected change in life expectancy and its impact on success rates. A shorter expected time horizon for a poorer initial health state means a lower likelihood that the portfolio will be exhausted prematurely. Examining the differences in modeling costs, Framework 3 overestimates success rates and underestimates health care costs in the extreme bad health states because of an understated health care cost.

Figure 4. Value of stochastic modeling of health care costs may seem to be limited when only comparing success rates

a. Single female

	Initial health state	Success rate	Average health care cost
Framework 3	Good	70.1%	$3,000
	Fair	74.4	
	Light LTC	78.8	
	Severe LTC	85.5	
Framework 4	Good	72.1%	$2,866
	Fair	75.1	3,110
	Light LTC	79.0	3,249
	Severe LTC	84.4	3,891

b. Female in a couple

	Initial health state	Success rate	Average health care cost
Framework 3	Good	63.8%	$3,000
	Fair	67.7	
	Light LTC	72.2	
	Severe LTC	80.3	
Framework 4	Good	66.7	$2,731
	Fair	69.3	2,913
	Light LTC	73.2	3,039
	Severe LTC	79.9	3,493

Source: Vanguard calculations, based on data from VCMM, the Social Security Administration, and the Health and Retirement Study.

From Frameworks 3 to 4, where the average costs are similar for a particular demographic, it can appear that more sophisticated health care cost modeling has limited value because the success rate is an aggregate measure of outcomes. The stochastic modeling of health care costs can provide important insights into the stability of spending for different demographic groups, however.

In **Figure 5**, we show that the annual health care cost for the single female retiree in good health at age 65 can vary widely, from about $1,600 to $18,000. The deterministic assumption could underestimate the annual health care cost by as much as $15,000 and overestimate it by as much as $1,400.

This variation can account for a sizable chunk of the annual spending target, as shown in Panel B in Figure 5. The uncertain health care cost, on average, accounts for about 3.3% to 27.7% of a retiree's total annual spending target. This exercise reveals a nuanced but important fact about the health care cost risk: Uncertain health care cost can undermine the stability of spending. In the context of planning, a fixed spending rule may be an inferior strategy because it cannot meet uncertain and highly variable health care needs without sacrificing the stability of other living costs.

Figure 5. Stochastic modeling of health care costs illustrates the stability issue in a fixed spending strategy

Single female in good health

		Average expense	Maximum	Minimum	Standard deviation
Panel A: Average annual health care cost	Framework 4	$2,635	$18,046	$1,605	$1,620
	Framework 3	$3,000	$3,000	$3,000	$0
	Framework 4 minus 3	–$365	$15,046	–$1,395	$1,620
Panel B: Health care cost as percentage of target spending	Framework 4	5.0%	27.7%	3.3%	3.3%
	Framework 3	6.0%	6.0%	6.0%	0.0%
	Framework 4 minus 3	–1.0%	24.3%	–3.1%	3.3%

Note: Average expense refers to out-of-pocket health care cost excluding insurance premiums.

Source: Vanguard calculations, based on data from VCMM, the Social Security Administration, and the Health and Retirement Study.

Conclusion

The general conclusion is clear: Richer models that can incorporate sources of uncertainty such as health state and longevity in a personalized way will help advisors provide their clients with deeper insights into the longevity risks they need to plan for and strategies they can use to manage them.

Our research shows that a deterministic view of health care cost may be just fine when assessing the sustainability of a particular spending strategy. However, our results reveal another important role of health care risk in retirement planning—how uncertain health care costs affect the chances of achieving a stable standard of living in retirement. We plan to explore this topic in a future *Perspectives*.

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Appendix

About the Vanguard Capital Markets Model

IMPORTANT: The projections and other information generated by the Vanguard Capital Markets Model regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time.

The VCMM projections are based on a statistical analysis of historical data. Future returns may behave differently from the historical patterns captured in the VCMM. More important, the VCMM may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

The Vanguard Capital Markets Model® is a proprietary financial simulation tool developed and maintained by Vanguard's primary investment research and advice teams. The model forecasts distributions of future returns for a wide array of broad asset classes. Those asset classes include U.S. and international equity markets, several maturities of the U.S. Treasury and corporate fixed income markets, international fixed income markets, U.S. money markets, commodities, and certain alternative investment strategies. The theoretical and empirical foundation for the Vanguard Capital Markets Model is that the returns of various asset classes reflect the compensation investors require for bearing different types of systematic risk (beta). At the core of the model are estimates of the dynamic statistical relationship between risk factors and asset returns, obtained from statistical analysis based on available monthly financial and economic data from as early as 1960. Using a system of estimated equations, the model then applies a Monte Carlo simulation method to project the estimated interrelationships among risk factors and asset classes as well as uncertainty and randomness over time. The model generates a large set of simulated outcomes for each asset class over several time horizons. Forecasts are obtained by computing measures of central tendency in these simulations. Results produced by the tool will vary with each use and over time.

Figure A-1 shows the success-rate results for male retirees with different relationship status and initial health state conditions.

Figure A-1. Male investors tend to have shorter life expectancy and higher success rates than comparable female investors

a. Single male

	Initial health state	Life expectancy	Success rate	Average health care cost
Framework 3	Good	82.1	84.4%	$3,000
	Fair	80.5	86.8	
	Light LTC	78.2	89.7	
	Severe LTC	74.9	93.7	
Framework 4	Good	82.1	86.5%	$2,280
	Fair	80.5	88.0	2,499
	Light LTC	78.2	90.1	2,827
	Severe LTC	74.9	94.0	2,727

b. Male in a couple

	Initial health state	Life expectancy	Success rate	Average health care cost
Framework 3	Good	84.9	77.4%	$3,000
	Fair	83.0	80.7	
	Light LTC	80.7	84.4	
	Severe LTC	76.8	89.5	
Framework 4	Good	84.9	80.2%	$2,262
	Fair	83.0	82.5	2,469
	Light LTC	80.7	85.9	2,494
	Severe LTC	76.8	90.0	2,940

Source: Vanguard calculations, based on data from VCMM, the Social Security Administration, and the Health and Retirement Study.

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