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OPTIMIZING RETIREMENT FINANCIAL STRATEGIES: INTEGRATING ANNUITIES, DEFINED CONTRIBUTION PLANS, AND LONG-TERM CARE COSTS

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ABSTRACT

Nursing home costs in the United States now exceed $100,000 per year, and government assistance programs such as Medicaid help out only when retirees are largely destitute. Moreover, health shocks driving the need for such care can arise suddenly in old age, are frequently permanent in nature, and can be associated with declining mental and physical abilities. These facts raise the important question of how households can best prepare to finance this final phase of life. Building on past research, we determine how retirees should manage payouts from defined contribution plans to balance trade-offs between consumption and health care cost shocks, using both retirement plan assets and annuitization. Our analysis explicitly integrates the role of taxes, required minimum distributions, bequest motives, and the possibility of retiree insolvency. We conclude that payout annuities, especially deferred and variable annuities, can be quite valuable for retirees, even when they face health shocks in later life.

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Optimizing Retirement Financial Strategies: Integrating Annuities, Defined Contribution Plans, and Long-Term Care Costs

One of the most important financial risks facing individuals in later life is the need to cover nursing home costs. An estimated 70% of persons age 65+ will need some form of long-term care (LTC) over their lifetimes. Moreover, people spend an average of 3.2 years in care, and 20% require such care for five or more years (Samuels, 2023). About one in 10 will incur out-of-pocket LTC expenses totaling over $200,000+ (Braun et al., 2019). Moreover, health shocks driving the need for such care can arise suddenly in old age, are often permanent, and can be associated with declining mental and physical abilities. This raises the crucial question of how people can best prepare to finance this potentially quite costly final phase of life, using financial instruments currently available in the marketplace.

There are essentially three options for financing LTC in the United States. The government Medicaid program is a secondary payer, stepping in only after retirees have nearly exhausted their assets and depleted their Social Security and other retirement benefits. Additionally, Medicaid imposes strict guidelines on nursing home amenities and services provided, which, for many Americans, will not result in the quality of life they would prefer.[1] The market for private long-term care insurance (LTCI) has faced persistent challenges for decades, resulting in high premiums due to adverse selection, as well as high administrative costs for underwriting and claim management compared to other life insurance products, all of which impair the efficiency and attractiveness of LTCI for both providers and consumers (e.g., Brown & Finkelstein, 2007). Consequently, relatively few people purchase private LTCI at present.[2] Realistically, therefore, most Americans must self-insure against the financial risks of LTC by continuing to hold assets throughout old age.

One way retirees can deploy such assets is via employer-sponsored defined contribution (DC) plans and individual retirement accounts (IRAs), now amounting to over $29 trillion (ICI, 2025). Usually, such vehicles hold liquid assets such as bonds, equities, or mutual funds, which individuals can draw down as needed to cover long-term expenses. An alternative approach is to convert these assets into lifetime income streams, which then can help pay for LTC costs (at least in part). This has been spurred by U.S. regulatory changes starting in 2014, along with the

[1] Although many Americans may believe that the Medicare program pays for LTC costs, it does not (Medicare.org, n.d.).

[2] Braun et al. (2019) noted that only 10% of retired Americans own a private LTCI policy, and the number of individuals with LTCI has been steadily declining over the past decade. Innovative proposals for new products such as life-care annuities have not emerged in practice (e.g., Brown & Warshawsky, 2013; Coy, 2023; Gong & Webb, 2010).

more recent SECURE 1.0 and 2.0 Acts of 2019 and 2022, respectively, making lifetime income annuities progressively more attractive.[3] As a result, plan sponsors are now increasingly willing to include qualified longevity annuity contracts (QLACs) in DC plan menus, as well as attractively priced deferred annuities in target date funds intended for retirees who continue to hold DC assets.[4] Such annuities pay lifelong benefits to retirees beginning several years after the premium is paid, but not later than age 85. Due to the pooling of longevity risks and discounting, deferred annuities allow retirees to receive relatively high payouts late in life, at a relatively low cost. Importantly, as there's a greater chance of needing LTC late in life, the annuity benefit can help cover LTC expenses.

This paper explores *how much* and at *which deferral age* individuals should optimally purchase longevity income products using accumulated DC assets, taking into account the risk of needing money to cover LTC costs late in life. Our approach incorporates consumer heterogeneity and realistic institutional rules (e.g., for taxes, for tax-qualified DC plans, and Social Security benefits), as well as the risk of needing LTC and the roles of Medicare and Medicaid.

We devote particular attention to when the deferred annuity should begin paying out. If benefit payments start too early, the (nonrefundable) premium is more expensive, making investors reluctant to buy the lifetime income product. If benefits begin later, the annuity is less expensive, but too few retirees may survive long enough to receive benefit payments. Accordingly, our analysis addresses the following specific research questions: Should LTC costs be optimally financed solely from assets held in tax-qualified DC retirement plans, or should at least some of retirees' DC assets be annuitized to help cover future costs? What's the optimal deferring age for QLACs in tax-qualified retirement DC plans, considering retiree characteristics such as their lifetime labor incomes, sex, mortality patterns, health care risk, and bequest motives? To what extent would optimal deferring ages differ for payout annuities with *fixed* versus *variable benefits*, where the latter are linked to the return of an underlying portfolio of risky stocks and bonds (e.g., within a *participating annuity* or *investment-linked annuity*)?

Related Literature

Our research is related to a number of papers in the rich household finance literature on consumer saving and financial decision making.[5] Specifically, we build on prior work on

[3] Specifically, the 2019 SECURE 1.0 Act provided plan sponsors "safe harbor" rules if they offered such longevity protection products in their DC plan investment menus. Additional efforts to make income annuities more attractive were included in the 2022 SECURE 2.0 Act, which boosted tax-protected contribution limits for QLACs.
[4] For a recent overview of the market, see Kephart and Dziubinski (2024).
[5] See Gomes (2020) and Gomes et al. (2021) for excellent overviews of the literature.

household consumption and portfolio choice over the life cycle, initiated by Cocco et al. (2005) and Gomes and Michaelides (2005), which employs discrete-time models incorporating uncertain labor income and stock market risk. Subsequent studies have extended this framework along several dimensions, by introducing additional exogenous risk factors, expanding the available investment universe, and including key institutional features such as taxation, Social Security, and regulatory constraints that shape household financial decisions.

One important strand of this literature focuses on exogenous health-related risks. As emphasized by Love and Smith (2010), individuals' health status is inherently uncertain and influences their economic behavior through two key channels: Declining health can increase mortality risk and shorten life expectancy, and it can also expose retirees to substantial, unpredictable out-of-pocket medical expenses.[6] De Nardi et al. (2010) incorporated these risks in a structural life cycle savings model by allowing for age- and health-dependent uncertain medical expenditures. Their framework featured two health states (good and poor) and modeled transitions between them using an inhomogeneous Markov chain with age-varying, uncertain transition probabilities. They found that, under health-related uncertainty, bequest motives play only a minor role in explaining high savings among older individuals.

Building on this foundation, Ameriks et al. (2011) and Reichling and Smetters (2015) extended the two-state health framework by introducing a third state, representing individuals unable to perform activities of daily living and then require LTC. They also expanded the financial environment by allowing individuals to use accumulated assets to purchase life annuities. A key insight of both papers is that LTC risk reduces the demand for annuities and that annuitization only becomes optimal once households have accumulated a certain minimum level of wealth. Peijnenburg et al. (2017) further enriched the investment setting by incorporating bonds, risky equities, and annuities, and those authors compared models of health transitions and associated medical costs.[7] While their results showed that health risks reduced annuity demand, they couldn't fully explain the "annuity puzzle"—the empirically low take-up of private annuities relative to theoretical predictions. By introducing a four-state health

[6] A third channel through which health risk shapes economic behavior is via diminished labor productivity and, consequently, reduced earnings. This mechanism, however, is beyond the scope of this study.

[7] Peijnenburg et al. (2017) also provided an overview of different health risk models in life cycle settings. Related studies include Yogo (2016) who link health shocks to medical spending and insurance frictions, Braun et al. (2019) who model detailed Medicare policy features, and Blundell et al. (2024) who highlight dynamic interactions between health, work, and inequality.

process, Lockwood (2018) demonstrated that a strong bequest motive is a key factor in aligning model predictions with observed annuitization behavior.

A second strand of related literature focuses on models that explicitly incorporate employer-sponsored DC plans such as 401(k) and 403(b) plans, as well as IRAs. These represent the principal form of financial wealth accumulation for many U.S. households. In 2025, private-sector DC plans held \$12.2 trillion in assets for roughly 85 million active participants, while IRAs managed an additional \$16.8 trillion on behalf of 58 million U.S. households (ICI, 2025). DC retirement plans are attractive due to tax benefits and employer matching contributions, but they're also characterized by illiquidity before people attain a certain age and impose complex tax and regulatory rules on contributions and withdrawals. Life cycle models that incorporate these institutional features were developed by Love (2007) and Gomes et al. (2009). More recently, Horneff et al. (2020, 2023a, 2023b, 2025) extended these models by allowing 401(k) participants to allocate retirement assets not only to risky and risk-free investments but also to QLACs, consistent with IRS regulations. Results showed that access to QLACs can significantly improve welfare, thus supporting the inclusion of deferred annuities in default decumulation strategies. Nevertheless, while that work incorporated stochastic out-of-pocket medical expenses, it didn't link declining health status to mortality rates, nor did it consider the possibility of entering LTC and incurring the associated costs.

The present paper bridges these two previously separate strands of the literature by embedding annuitization decisions within the institutional context of 401(k) plans, while explicitly accounting for LTC risk and health-related mortality. This integration offers both theoretical and practical advantages over past research. Specifically, 401(k) plans provide a natural platform for annuity purchases due to features such as risk pooling, administrative efficiency, and pricing leverage, while also allowing for a joint assessment of health risks and institutional frictions over the life cycle.

In what follows, we extend prior work by evaluating the welfare effects of alternative annuitization designs across demographic groups, under existing regulatory constraints. Our life cycle framework combines health-contingent annuity demand with optimal decumulation in DC plans, accounting for exogenous health shocks and LTC needs. By modeling the full life cycle, we endogenize retirement wealth accumulation through earnings, saving, health events, and annuity choices. Importantly, we also consider a broader range of annuity products than examined previously, including deferred annuities (e.g., QLACs) and variable lifetime payouts, better reflecting the complexity of real-world retirement options.

Analytical Framework and Methodology

We next describe our model that incorporates uninsurable labor income risk, capital market risk, longevity risk, and the risk of needing nursing home care in old age. Health transitions are governed by an inhomogeneous Markov chain, calibrated using data from the Health and Retirement Study (HRS). Our framework also explicitly covers 401(k) plan rules, including contribution limits and the option to purchase deferred annuities with retirement assets. If LTC expenses exceed financial resources, retirees may face bankruptcy and become eligible for Medicaid-like public support. Using this life cycle approach, we generate optimal consumption, portfolio allocations, and holdings of risky stocks, bonds, and longevity income annuities, given a deferral age for the longevity income to start paying benefits.

Model setup and utility specification: Building on and extending our previous work,[8] we use a dynamic life cycle model to generate optimal outcomes for a utility maximizing U.S. individual who makes a series of annual decisions from $t = 1$ (age 25) to maximum $T = 76$ (age 100) regarding consumption, contributions to and withdrawals from tax-qualified 401(k)-style retirement accounts, portfolio allocations between risky stocks, bonds, and life annuities. The individual's lifetime can be divided into two distinct phases: a working period starting at age 25 ($t = 1$) and a retirement period beginning at age 66 ($t = K = 42$) and continuing until death. The worker earns an uncertain labor income, and in retirement, receives lifelong Social Security benefits, which depend on average lifetime earnings. Throughout the life cycle, the individual must cover housing expenses and income taxes, and during the working years, pay Social Security contributions.

Preferences are defined over consumption C_t and bequest Q_{t+1} according to a recursive Epstein-Zin (1989) utility function with intertemporal elasticity of substitution ψ, relative risk aversion ρ, and time preference β. Bequests can be made from the financial wealth both inside and outside tax-qualified retirement accounts. The strength of the bequest is controlled by the parameters b and ϕ measuring the extent to which the bequest is a luxury good (Ameriks et al., 2011). The period t value function satisfies:

$$J_t = \left\{ C_t^{1-\frac{1}{\psi}} + \beta E\left[\sum_k H_{kh,t} \sum_i \Pi_{ij,t} \left(p_{h,t}^s (J_{t+1})^{1-\rho} + (1-p_{h,t}^s) b \left(\phi + \frac{Q_{t+1}}{b}\right)^{1-\rho}\right)\right]^{\frac{1-\frac{1}{\psi}}{1-\rho}} \right\}^{\frac{1}{1-\frac{1}{\psi}}} \tag{1}$$

[8] See Horneff et al. (2020, 2023a, 2023b). Other relevant works include Kim et al. (2016) and Hubener et al. (2016).

Here, the expectation integrates over both the labor income transition matrix $\Pi_{ij,t} = Prob(l_{t+1} = i|l_t = j)$ and the health transition matrix $H_{kh,t} = Prob(hs_{t+1} = k|hs_t = h)$. The age-dependent income matrix represents the probability of moving from current income level j to income level i one year later. The health transition matrix is also age-dependent and specifies the probability of moving within one year from one current health state $hs \in \{g, p, n\}$—good health, poor health, or in the nursing home—to another (possibly different) health state. Conditional on the individual's current health state, $p_{h,t}^s$ denotes the probability of survival from t to $t + 1$.

Individuals are heterogenous with respect to labor income, health transition rates, and survival rates, which depend on sex (male, female) and education level (<*HS* high school dropouts, *HS* high school graduate, or at least some college *Coll+*). In total, our model is calibrated and evaluated for six distinct demographic subgroups, defined by the intersection of sex and educational attainment.[9] We calibrate the preference parameters using the simulated method of moments, aligning model-generated 401(k) mean wealth balances with empirical data from the PSID across five age brackets: 25–29, 30–39, 40–49, 50–59, and 60–69. Specifically, we simulate 100,000 life cycle trajectories with optimal decisions separately for males and females, with respect to the exogeneous shocks (income, health status, and stock returns).[10] Within each sex group, simulated paths are proportionally distributed according to their empirical population shares. The resulting subgroup averages are then aggregated into a total population mean using sex-specific population weights. We iteratively adjust preference parameters to minimize the squared percentage deviations between the simulated and empirical 401(k) wealth levels across the five age groups. This procedure generates values for risk aversion $\rho = 5$, discount factor $\beta = 0.94$, elasticity of intertemporal substitution $\psi = 0.2$, the luxury bequest parameter $\phi = 5$, and the strength of the bequest $b = 5$. These are consistent with other life cycle models cited previously and also closely match our outcomes to empirical evidence.

[9] Technical details regarding the calibration and formulation of the life cycle model, such as budget constraints, evolution of cash on hand, taxation, 401(k) regulations, and other institutional features, are given in Appendix A.
[10] We solve the life cycle model recursively through time via backward induction for each of the six demographic subgroups numerically, using parallel computing with high-performance cluster technology. The numerical procedure uses a six-dimensional discrete state space grid 40(*X*)×20(*L*)×15(*PA*)×3(*l*)×3(*hs*)×76(*t*), with *X* being cash on hand, *L* 401(k) assets, *PA* annuity income, *l* income level, *hs* health state, and *t* time. The expectation of the multivariate log-normally distributed random variables is computed using Gauss–Hermite quadrature with nine quadrature nodes per variable and use cubic spline inter- and extrapolation for points outside the grid.

With respect to capital markets parameters, we assume a 2% risk-free rate, a risk premium of 4%, and a return volatility of 18%, in line with a diversified stock portfolio, with investment returns subject to income and capital gains taxes. For the labor income implementation, we draw on Horneff et al. (2023a) and update the PSID data underlying that analysis to 2021 (all values are reported in $2021). Housing cost parameters are calibrated as a percentage of labor income, as in Love (2010). Our model assumes that workers retire at age 67 and claim their Social Security old-age benefits based on a formula that relies on their 35 best years of earnings and the bend points as of 2021. The maximum annual labor income on which Social Security benefits are calculated is $142,800 (in $2021). In line with U.S. rules, we compute federal income taxes based on the individual's taxable income and six income tax brackets and the corresponding marginal tax rates. A list of calibrated parameters is presented in Appendix Table A.5.

Tax-deferred retirement accounts: In contrast to investments in bond and risky stocks held in non-tax-qualified accounts, elective employee contributions to 401(k)-style retirement accounts (matched by employers) and their investment returns are tax-deferred. Our model explicitly incorporates the regulations governing such plans, including contribution and matching limits, early withdrawal penalties, and required minimum distributions (RMDs). We assume that retirement assets are invested in a target date fund, which gradually reduces equity exposure according to a predefined glidepath by age. At the retirement age $t = K$, individuals may use a portion of their accumulated 401(k) balances to purchase (deferred) life annuities, subject to the IRS regulations governing QLACs.

Specifically, we model the institutional parameters of 401(k) plans as follows: workers' maximum permitted elective contributions to their retirement accounts equal an annual $19,500 to age 51, with an additional catch-up contribution permitted of $6,500 per year after that. The employer's matching contribution is assumed to be at a one-to-one rate up to 5% of the worker's earnings, up to an annual cap of $14,500. We also take into account the RMD rules that require the retiree to take out a specified percentage of their 401(k) assets (as per the IRS 2022 requirements).

Health and survival: We integrate health state risk in our life cycle model starting at retirement. Health doesn't enter the utility function explicitly. Instead, it affects welfare only indirectly via out-of-pocket medical costs, health-dependent survival probabilities, and the potential to depend on government assistance. All retirees start retirement in good health, after which their health evolves exogenously as an inhomogeneous Markov chain with three states, $hs \in \{g, p, n\}$, corresponding to good health, poor health, and needing nursing home care. If the individual is in good health, no medical assistance is required. Poor health reflects a deterioration in physical or cognitive condition necessitating treatment, though not institutionalization. Individuals residing in nursing homes require institutionalized LTC. The probability of transitioning from health state h at age t to k in $t+1$ is denoted by:

$$H_{kh,t} = \Pr(hs_{t+1} = k \mid hs_t = h, t), \tag{2}$$

with all possible health transitions forming a full 3×3 switching process for each sex and education subgroup. This setup captures health trajectories more realistically than a binary model of institutionalization. It allows for gradual health deterioration, acknowledging that individuals don't typically transition directly from good health to institutional care. This structure also permits a detailed representation of health dynamics, which is important because health status systematically influences both medical spending and retirement-related financial behavior.

During retirement, survival probabilities depend on the individual's health status. The probability of surviving from age t to $t+1$, conditional on being in health state hs_t, is given by:

$$p_{h,t}^s = \Pr(alive_{t+1} \mid hs_t = h, t), \tag{3}$$

allowing for differentiated mortality risk across health states and individual characteristics. These components jointly determine individuals' exposure to health shocks and longevity risk during retirement.

We assume mortality rates to age 50 following the Arias et al. (2023) population life table for the year 2021, adjusted by sex and education according to Krueger et al. (2015). For ages 50–67, we use our estimated survival probabilities in good health. This structure avoids discontinuity at retirement: If survival estimates based on the population life table were used to age 67 but replaced by health-specific survival probabilities at retirement, a mechanical increase in survival at age 67 would occur. This would distort consumption and asset profiles due to a jump in expected longevity. At age 50, the difference between population-based and good-health survival probabilities is minimal, such that transitioning to our estimations at this point doesn't affect life cycle profiles. From age 67 upward, individuals are assumed to die according to their health-specific mortality rates by sex and education.

To estimate survival probabilities, we use the RAND HRS Longitudinal File 2020 (Version 1). We construct a binary indicator of survival over biennial survey years. For each sex/education subgroup and the overall sample, we estimate a Logit regression of survival on a quadratic in age, health status, and their interactions. Annual survival probabilities are obtained by taking the square root of the estimated two-year probabilities.

Figure 1 illustrates expected remaining lifetimes by age and health status estimated for the entire HRS population and compares them to the 2021 unisex expected remaining lifetimes of Arias et al. (2023). Dotted grey lines represent estimates for each health state. The solid black line is a health-state-weighted average using the empirical distribution of health states by age in the HRS sample.

Figure 1 here

We estimate the health transition dynamics between three health status groups using the same HRS data where people self-report being in good health, poor health, or being in a nursing home. We classify respondents as being in "good" health if they self-report being in excellent, very good, or good health, and in "poor" health if they self-report being in fair or poor health, following De Nardi et al. (2016). We classify individuals as being in a nursing home if they're recorded as staying at least 120 days in a nursing home over the last two years, or if they stayed at least 60 days and then died, as in De Nardi et al. (2025). Using these data, we run a multinomial Logit regression model of future health status on current age and health status, fitted separately by sex and education group. We then construct the annual inhomogeneous Markov chain by applying the matrix square root to the estimated two-year process.

Using survival and transition probabilities estimated for the overall sample, we simulate a population and compare nursing home residency rates to empirical data. Table 1 shows, for different age groups, the share of individuals age 65+ residing in nursing homes based on data from the U.S. Census Bureau (2020). It demonstrates that these figures closely match the corresponding results taken from our Markov-switching model for the population.

Table 1 here

Figure 2 displays the share of individuals residing in nursing homes by age, sex, and education, revealing notable heterogeneity by subgroup. The share of the overall population in nursing home peaks around age 87, with higher rates among women. Greater educational attainment is associated with a later peak in nursing home residence. For example, the value of 3.48% at age 90 for Coll+ women indicates that 3.48% of individuals in this group who entered retirement in good health at age 67 are still alive and reside in a nursing home at age 90. The decline in nursing home residence with age is explained by higher mortality rates later in life.

Figure 2 here

Medical expenses and Medicaid: We model individuals' medical expenses, MC_{hs}, as exogenous and state-dependent: Its level is a fixed dollar amount that depends only on the current state of health and not on age, income, or wealth,[11] and we abstract from explicit end-of-life costs. Specifically, we adopt the values reported in Ameriks et al. (2011) adjusted for inflation to \$2021. Thus, we assume no cost for retirees in a good health state ($MC_{g,t} = \$0$), costs of $MC_{p,t} = \$14{,}000$ for people in a poor health state, and when retirees are in such bad health that they must move to a nursing home, we assume annual costs of $MC_{n,t} = \$70{,}000$.

If retirees are unable to self-finance medical expenses using personal resources, a means-tested public insurance scheme mirroring key features of the U.S. Medicaid system applies a two-stage "spend-down" process. First, the program protects a small amount of income for basic personal consumption, depending on the retiree's health state. For individuals in nursing homes, this allowance is lower than for those in poor health but living independently, reflecting in-kind coverage of food, shelter, and basic services. Second, any remaining assets are used to cover the medical costs. This includes income from labor, Social Security, and annuity benefits, as well as returns from investments in stocks and bonds and withdrawals from retirement accounts, all net of housing costs and taxes. Any remaining medical balance is then drawn from available 401(k) balances. Medicaid covers only the shortfall after these resources are exhausted.

If retired individuals cannot cover these medical expenses from available income and financial assets, they then become eligible for the Medicaid program. In poor health, the personal needs allowance is calibrated to the 2021 U.S. federal poverty line for single-person retired households at \$12,880. For nursing home residents, the exempt allowance is set to \$9,528, which is the maximum Supplemental Security Income (SSI) in the year 2021. These thresholds determine the protected portion of after-tax income. In either case, before Medicaid covers any remaining medical expenses, retirees are required to spend down their 401(k) assets through withdrawals taxed as personal income.

The decision to annuitize: At retirement, individuals may convert a part (DA_K) of their 401(k) balances (L_t), into a QLAC, subject to prevailing regulatory limits, with a maximum allowable allocation of \$177,857 (in \$2021). In our baseline scenario, we assume a fixed annuity with lifelong constant payments starting at age 67. In the sensitivity analysis, we also explore deferred annuities permitted under current QLAC regulations, provided that benefit payments commence no later than age 85. In addition to fixed annuities, we also consider (deferred) investment-linked variable payout annuities, in which benefit levels fluctuate based on the

[11] In contrast, Pang and Warshawsky (2010) and Yogo (2016) assume that LTC costs are a percentage of income, but this is at odds with how actual LTC costs are charged. Peijnenburg et al. (2017) do model absolute health care cost levels and allow annuitization, but their LTC costs are not modeled as persistent. They also don't incorporate tax-sheltered DC retirement plans or deferred annuities.

realized returns of an underlying portfolio composed of stocks and bonds.[12] To examine the utility implications of variable annuities and the trade-offs associated with deferring income in exchange for higher expected payouts, we vary the QLAC starting point across three ages, namely 75, 80, and 85.

Annuity prices are derived following actuarial standards, as in Horneff et al. (2023a). Specifically, we use the Society of Actuaries (SOA, 2012) basic unisex mortality table with adjustments for mortality improvements through 2021 and apply an assumed interest rate of 2%, corresponding to the risk-free rate. It's important to emphasize that, within a 401(k) plan and under current regulations, differential annuity pricing based on sex isn't permitted. As a result, the mortality assumptions used for annuity pricing in DC plans differ from those underlying actuarial fairness, resulting in an implicit loading on the actuarially fair price. Table 2 confirms that these loadings differ substantially across the six demographic subgroups studied here.

Table 2 here

Results: Fixed Immediate Annuities

Figure 3 displays our results regarding the demand for immediate fixed annuities payable from age 67 for the six subgroups, expressed in terms of the fraction of the 401(k) assets converted to the lifetime income product. Panel A indicates the cumulative probability distribution of this ratio for females by education group, based on one million optimal simulated life paths per group, while Panel B reports the same for males. The horizontal axis represents the fraction of 401(k) wealth annuitized, and the vertical axis reflects the cumulative probability. Among the female Coll+ subgroup, half annuitize up to 30% of their retirement plan assets, and on average, they devote 24.7% of their 401(k) assets to this product. Moreover, many would prefer to spend more on this product, but they're capped by the institutional limits on annuity purchases using their 401(k) money. By contrast, the demand for annuities among less-educated females is lower: 70% of the HS graduates would buy a fixed lifetime annuity using an average of 8.3% of their 401(k) assets to allocate to the lifetime payout product. Finally, only 35% of the HS dropouts have a positive demand for this annuity and would spend very little on it (1.9% on average). Overall, annuity demand among males is lower. On average, the Coll+, HS, HS dropout groups spend 11.4, 1.7, and 0.6%, respectively, of their 401(k) wealth on these annuities.

[12] Although these aren't currently permitted under QLAC regulations (IRS, 2014), Horneff et al. (2023a) document that they would be welfare-enhancing for many retirees.

Figure 3 here

Clearly, males are less desirous than females of annuities due to their shorter life expectancy, as well as the fact that the annuity pricing uses unisex tables versus actuarially fair pricing. The educational differences are to some extent attributable to the fact that better-educated persons live longer (a fact not taken into account by the unisex pricing). An additional factor driving the results is that the better educated have higher financial wealth levels at the age of 67. As a result, they're more likely to be able to cover nursing home costs on their own, so they demand annuities for their longevity projection and to earn the survival credit. The least educated, in contrast, have little financial wealth and face a higher risk of entering nursing homes early. Accordingly, they wish to retain their assets in liquid form to mitigate potential health care and nursing home cost shocks.[13]

This conclusion is supported by the results in Figure 4, where we show mean annuitization rates as a function of retirees' 401(k) wealth at age 67. Panel A reports results for females in the three education categories, and Panel B for males. Here, we document that the Coll+ females having 401(k) assets of \$150,000+ have a positive demand for annuities, beginning at around 5% of their retirement wealth and reaching a maximum at 40% for those having 401(k) wealth of \$425,000. Above that, retirees are capped by the threshold imposed by the QLAC regulation, resulting in a declining annuitization percent for those having accumulated more in their retirement plans. By contrast, the other two groups with less education don't begin to annuitize until they have around \$200,000 in their 401(k) accounts, and their annuitization rates are also lower. This difference is attributable both to their shorter remaining lifetimes and the higher chance that the less educated will need nursing home care at a younger age. These effects are even more pronounced for males, who annuitize at even higher thresholds. Thereafter, they have lower annuitization rates compared to females, and they reach the maximum allowable at higher asset levels, at about 25% with \$700,000 in 401(k) assets.

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[13] In this respect, our results are similar to those of Peijnenburg et al. (2017) and Reichling and Smetters (2015), yet our approach contributes novel insights by incorporating a richer institutional and individual heterogeneity framework. Unlike Peijnenburg et al. (2017), we account for heterogeneity in education, income, and liquid and retirement wealth, in addition to health trajectories. These dimensions shape life cycle paths and annuitization behavior in ways not captured by their model. Compared to Reichling and Smetters (2015), who allowed for repeated annual annuity decisions, we model a one-time purchase at retirement that better reflects real-world constraints. Annuity pricing also differs: Peijnenburg et al. (2017) use actuarially fair rates based only on gender and average health-adjusted survival, while we incorporate more realistic pricing that includes loadings and market frictions.

This is because they have shorter life expectancies and also a greater chance of entering a nursing home earlier in life.[14]

Figure 4 here

Next, we explore in greater depth how the demand for annuities is shaped by health uncertainty and bequest motives. Both are key factors in the prior literature but haven't yet been brought together within the 401(k) context. That is, bequests are usually seen as decreasing the demand for annuities, along with health uncertainty. To analyze how integrating these two alters results in our richer context, we turn to Table 3, which reports annuitization rates by sex/education for four different life cycle model settings. In our base case, Column 1, we replicate the average annuitization rates discussed above, which includes both a bequest motive as well as health shocks. Column 2 removes the health shocks, assumes no medical expenses, and uses sex/education-specific mortality tables independent of the individual's health status (Arias et al. (2023) adjusted as in Krueger et al. (2015)). Column 3 removes the bequest motive, and Column 4 removes both the bequest motive and health shocks. Model outcomes are generated using one million starting values (at age 66) for all state variables (i.e., 401(k) assets, cash on hand, and permanent income). To isolate the effect of bequests and health shocks on the demand for annuities (without affecting results due to different wealth effects), we employ the starting values generated using our base case model and use the same values to examine results in the other three settings.

Table 3 here

When health shocks are relevant, a comparison of Columns 2 and 1 shows that the demand for annuities declines for those with high school or less education. This is because these individuals more likely need to preserve their liquid financial resources in order to finance a possible nursing home stay, because entering a nursing home under Medicaid produces a dramatic decrease in consumption. By contrast, the demand for annuities rises among the Coll+ group when health shocks are introduced, most notably for women. This occurs for three reasons. First, when health shocks are introduced, this group has sufficient wealth to cover the costs of a nursing home stay without relying on Medicaid. Second, this group is less likely to require a nursing home and more likely to recover quickly, implying lower total liquidity needs. Third, this group, which faces additional uncertainty due to health shocks, has only two ways to mitigate it: either by investing more in bonds outside their 401(k) plans, which they do, or by buying annuities that produce predicable lifetime payouts.

[14] Additionally, Appendix Figure B.1 plots absolute annuitization amounts against 401(k) balances and cash on hand levels, showing that 401(k) balances generally exceed cash on hand holdings and that annuitization amounts rise with 401(k) wealth but vary little with cash on hand.

Less surprising is the finding that, without a bequest motive (Columns 3 and 4), the demand for annuities is always higher than in the corresponding models with bequests (Columns 1 and 2). It's also unsurprising that introducing health costs cuts annuity demand for all groups (compare Columns 4 and 3). These latter two results are in line with Peijnenburg et al. (2017).

Overall, introducing medical costs reduces the demand for annuities in the subgroups with relatively low financial assets, because their main concern is needing to finance an expensive nursing home stay that may come relatively early in life. For them, longevity risk is less of a concern. In contrast, better-educated and wealthier individuals can more easily finance their own LTC costs, so they can afford to take advantage of the benefits of an annuity giving them access to the survival credit.

Results: Deferred Fixed Annuities and Variable Annuities

We next examine how results change when the retiree can purchase a deferred annuity that starts paying at ages older than age 67. Here, we consider ages 75, 80, and 85. Subsequently, we discuss what happens when fixed annuities are replaced with variable annuities.

Deferred annuities: One reason that a deferred annuity might be preferred to an immediate annuity is that the retiree will receive higher benefits from the deferred product in exchange for the same initial outlay. In other words, deferred annuities provide retirees with a low-cost way to hedge the risk of outliving their assets. For instance, for $100,000, an immediate annuity payable at age 67 would provide a lifetime benefit of about $5,900 per year. For a deferral age of 80, the annual payout rises to $15,600 (at age 85, the annual benefit rises to $27,600). The disadvantage, of course, is that not everyone will live to the deferral age.

Table 4 Panel A illustrates annuitization rates for the four deferral ages under consideration for our six sex/education groups, where we see that all groups devote less of their assets to deferred annuities, compared to the base case. Among the best educated, the demand is still positive, but due to higher mortality, the less educated have essentially no annuity demand. To determine the effect on retiree utility, Panel A of Table 5 reports welfare gains for annuities payable at the different deferral ages. Here, the values reflect the additional dollar amount retirees lacking access to the annuity would need in their 401(k) plans at age 67, in order to make them as well off as with the annuity. The Coll+ female group with no access to annuities would need to be compensated with $34,000, compared to having access to a deferred annuity payable at age 80. This deferring age produces double the welfare gain, compared to the immediate annuity payable from age 67. In contrast, HS females favor immediate annuities versus the deferred products, as they face higher mortality and higher nursing home risk.[15]

Tables 4 and 5 here

Panel B in Table 4 reports results for males, where the demand for annuities follows a similar pattern but with lower overall annuitization rates due to their higher mortality rates. In addition, the 401(k) regulations require that unisex mortality tables be used in pricing the annuities. As a result, the implied loading on the annuity is higher for males. The implied loading is the difference between the actuarially fair annuity price (based on sex/education-specific mortality rates in line with our population model) and the price under unisex mortality rates as required by law. For example, the implied loading for a male Coll+ immediate annuity is 19% above its actuarially fair price, while for a female with the same education, the loading is only half that (9.5%, see Table 2). In addition, the loading rises with deferral age. That is, the loading for an annuity paying out from age 85 is about 51% for the Coll+ male group, and for the same deferral age, it's only 29% for the female Coll+ group.

Turning to welfare effects among the male retirees, Table 5 Panel A shows similar patterns to those of the females. The highest utility for Coll+ is provided by the annuity payout deferred to age 80, while the HS graduates do best with an immediate annuity. Overall, due to the higher implied loadings for men, utility gains are much lower—only one-third as large as for women for a payout beginning at age 80 (and only one-fifth as large for an immediate annuity).

Variable payout annuities: Next, we turn to examine annuitization and welfare results if the retiree can access a variable or investment-linked payout product, instead of a fixed payout annuity. Here, the lifetime payouts are linked to an underlying portfolio of mutual funds, offering both an investment and an insurance element that pools longevity risk across the retiree pool (Horneff et al., 2023a). In the United States, these aren't currently permitted under current QLAC rules, but as we show below, they are potentially of substantial interest for the retiree population.

In Panel B of Table 4, we report results for annuitization rates when the underlying portfolio consists of a 50/50 stock/bond portfolio. Overall, optimal annuitization rates rise for all deferral ages and for most sex/education groups (for HS dropouts, the demand is still very close to zero). The largest increase is observed for both male and female Coll+ groups, where the demand for the immediate annuity increase by around 10 percentage points. The reason is that these groups have a longer investment horizon and therefore seek to boost their annuity

[15] We do not report welfare gains for high school dropout retirees since their annuity demand is close to zero.

payouts. Among the less educated, annuity demand changes relatively little and remains close to zero for the HS dropouts.

Turning to the welfare results in Panel B of Table 5, we note that welfare gains for women are higher compared to the fixed annuity, and optimal deferral ages remain the same. For men, welfare gains are smaller from variable annuities, yet they are still positive. Overall, we conclude variable payout annuities can increase the welfare gains for most retirees, compared to the fixed annuity.

Conclusions and Implications

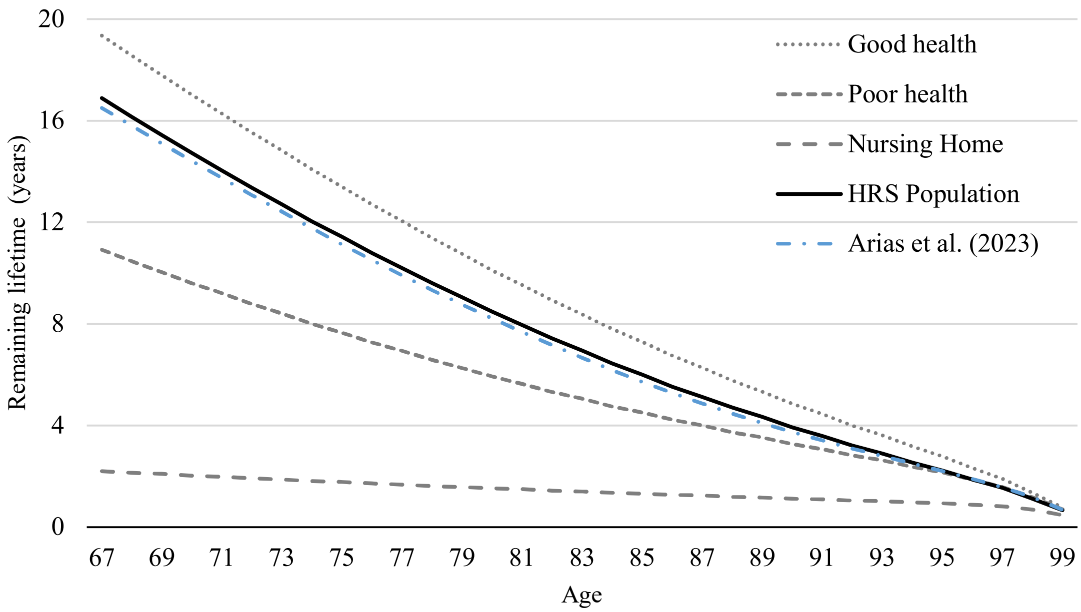
At the outset, we posed three questions, which we can now answer based on this research:

- *Should nursing home costs optimally be financed solely from assets held in tax-qualified DC retirement plans, or should at least some of retirees' DC assets be annuitized to help cover future costs?* We have demonstrated that, given current regulatory and tax rules as well as empirical evidence on health transition rates and medical costs in old age, better-educated retirees would do well to annuitize part of their 401(k) assets as they can benefit from longevity protection and earn the survival credit. The least educated tend to have little wealth and are at greater risk of entering nursing homes at earlier ages, so they prefer to keep their assets liquid in order to better manage unexpected health care and LTC expenses.
- *What's the optimal deferring age for QLACs in tax-qualified retirement DC plans, considering retiree characteristics such as their lifetime labor incomes, sex, mortality patterns, health care risk, and bequest motives*? Our results confirm that better-educated retirees favor annuity payouts deferred to age 80 as they have a longer investment horizon, while the less educated do better with immediate and smaller annuities. Nevertheless, utility gains for men are lower than for women due to their higher mortality rates.
- *To what extent would optimal deferring ages differ for payout annuities with fixed versus variable benefits, where the latter are linked to the return of an underlying portfolio of risky stocks and bonds (e.g., within a participating annuity or investment-linked annuity)?* Women experience greater welfare gains from variable annuities compared to fixed annuities, with no change in their optimal deferral ages. For men, welfare improvements are smaller but still positive, though their optimal deferral age declines. Variable payout annuities would clearly offer higher welfare gains for most retirees relative to fixed annuity options.

Overall, then, payout annuities are shown to be quite valuable, even when retirees face health shocks in retirement. Compared to our previous work, this more granular analysis of nursing home and mortality risks reveals that annuities are particularly attractive to the better educated who need to protect against greater longevity risk. In contrast, we find that the least educated with low life expectancies and a relatively high chance of needing nursing home care early in life have very little (if any) demand for annuities. Instead, they seek to hold on to their assets and avoid relying on Medicaid and the corresponding severe decline in consumption in the nursing home.

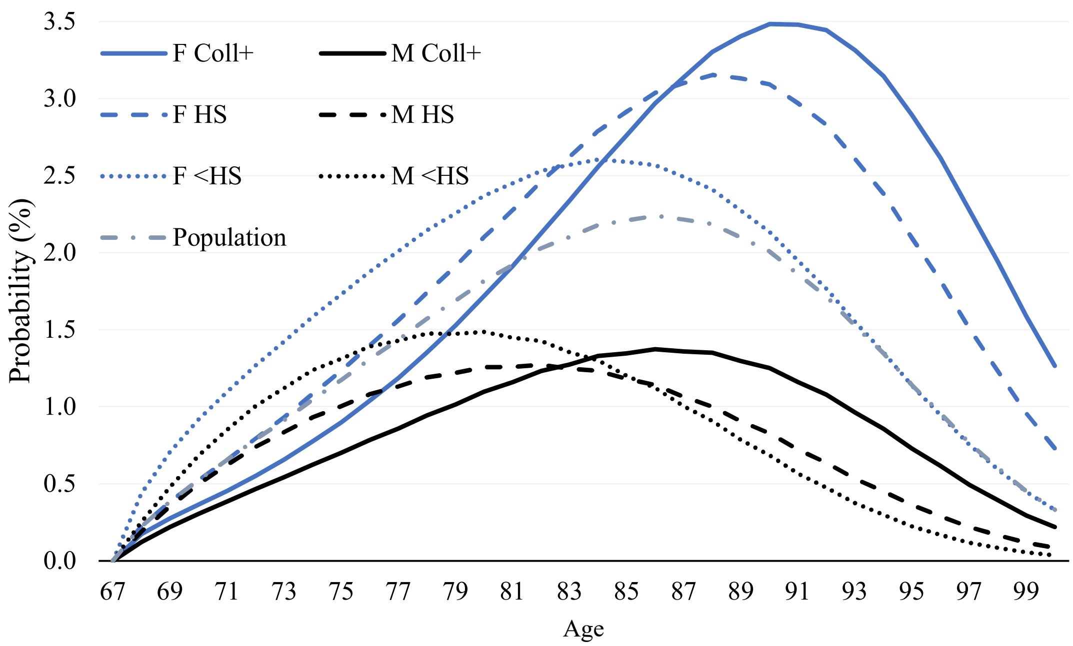
This research should be of clear interest to many stakeholders, including financial institutions seeking new ways to help manage the trillions in assets held by Baby Boomers as they move through retirement. Those offering retirement products such as insurers and mutual fund companies will also find our work useful in designing retirement solutions, as will financial advisors working with clients needing to manage their money in later life. Our results provide clear guidance about *when* to purchase these annuities, *how much* to purchase, and *when* the deferred benefits should start. Policymakers have also expressed interest in doing more to integrate lifetime income protection into DC plans (e.g., Gale et al. (2008)), and regulators will benefit from a clearer assessment of risks associated with IRAs, along with a possible role for regulation to protect individuals from the downside risk of fluctuating capital markets, health care costs shocks, and the risk of running out of money in retirement.

Figure 1. Expected remaining lifetimes: U.S. population table from Arias et al. (2023) and HRS estimates



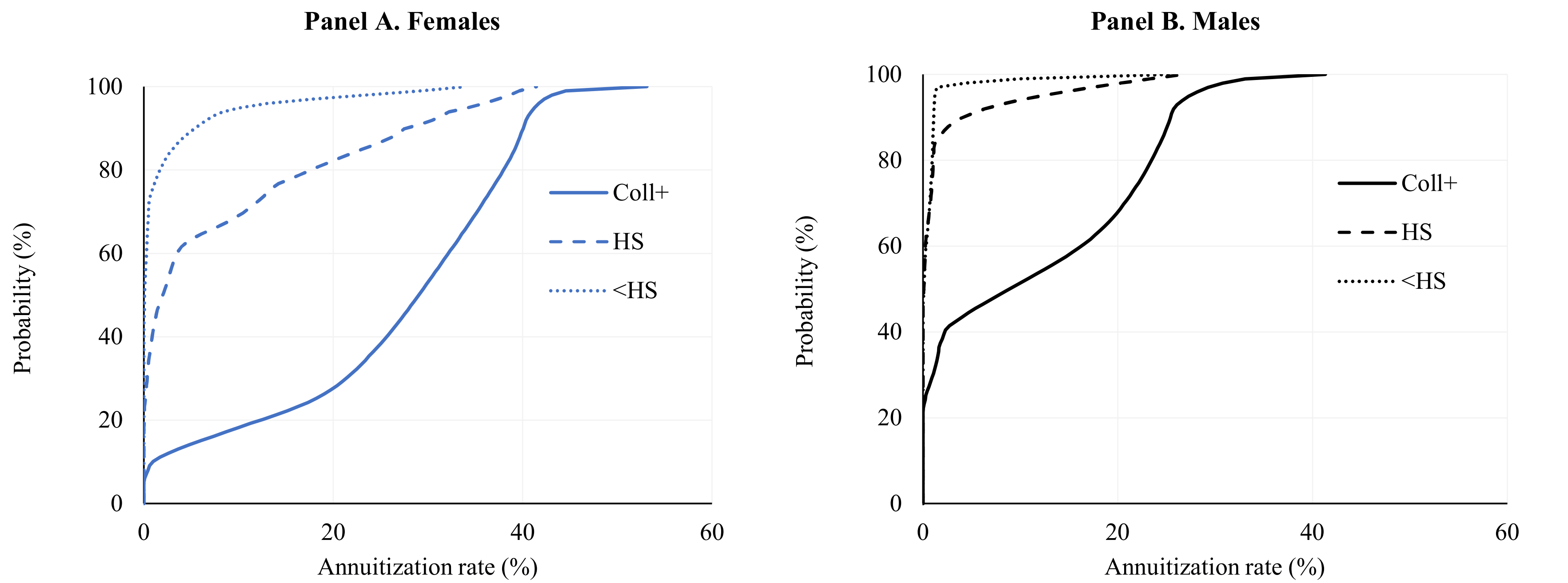
Notes: The figure shows expected remaining lifetime by age from two sources: (i) the unisex population life table for the year 2021 constructed from sex-specific survival rates from Arias et al. (2023), weighted by the empirical male–female composition, and (ii) our transition rate estimates from the HRS. The HRS-based lines represent expected remaining lifetimes under the assumption that individuals remain in a fixed health state—good health, poor health, or nursing home—until death, without transitioning. The solid black line is a health-state-weighted average, using the empirical distribution of health states by age in the HRS sample. *Source*: Authors' calculations (see text).

Figure 2. Probability of nursing home residence by age for six sex/education subgroups



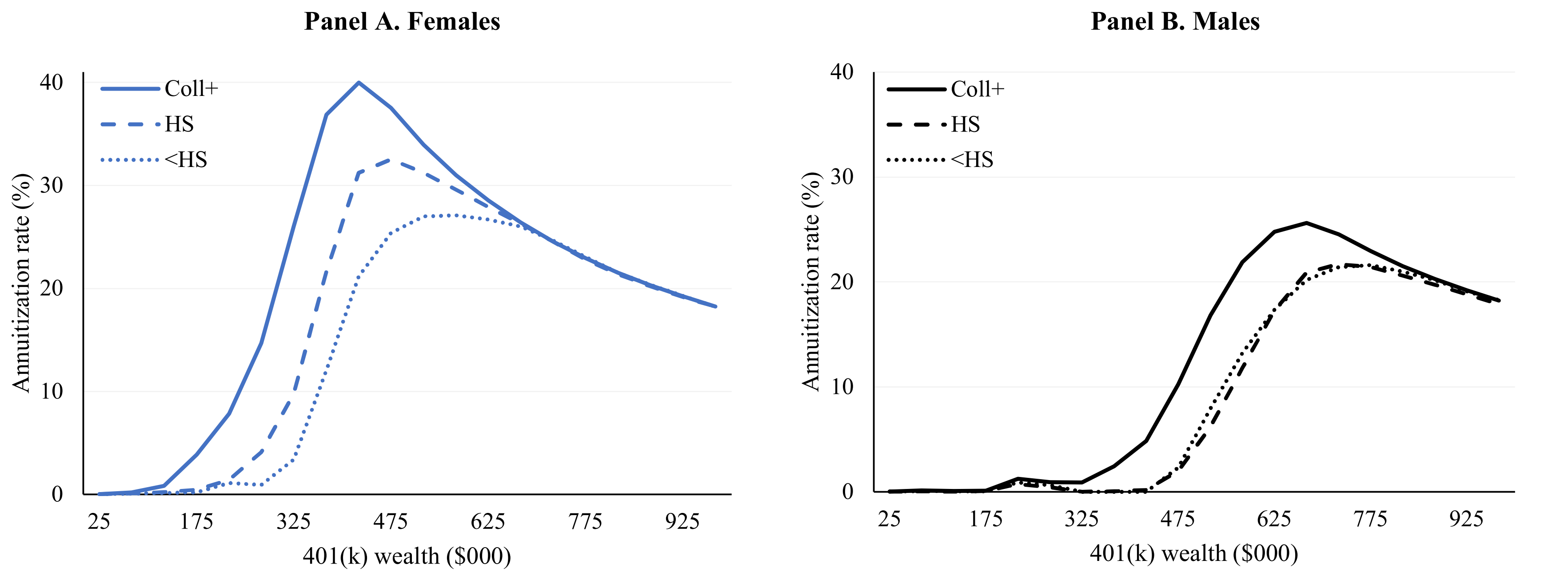
Notes: This figure illustrates the age-specific probability of residing in a nursing home, by sex and education. The population line represents estimates for the full HRS sample, without disaggregation by sex or education. Values reflect the share of individuals from an initial cohort—entering retirement in good health at the age 67—who are alive and in the nursing home state for ages up to 100. These probabilities are unconditional on survival and incorporate prior transitions across health state and mortality. Differences across demographic groups reflect heterogeneity in morbidity, survival, and institutionalization risk. *Source:* Authors' calculations (see text).

Figure 3. Cumulative distribution of the fraction of 401(k) wealth annuitized for six sex/education subgroups



Notes: This figure displays the cumulative distribution of the fraction of 401(k) wealth allocated to immediate annuities at retirement (age 67) for females and males, differentiated by educational attainment. For example, about 30% of Coll+ females annuitize at most 20% of their 401(k) wealth. Differences across groups are driven by unisex annuity pricing: Individuals with higher annuity loadings relative to the unisex mortality (e.g., lower-educated males) annuitize less, whereas individuals benefiting from more favorable pricing (e.g., better-educated females) allocate more to annuities. *Source*: Authors' calculations (see text).

Figure 4. Mean annuitization rate of 401(k) assets (by $50k bin) for six sex/education groups



Notes: This figure displays the mean fraction of 401(k) assets annuitized at retirement, calculated for $50,000 increments of age 67 balances. The top panel shows female cohorts and the bottom panel male cohorts, and each panel displays results for the different education groups. *Source:* Authors' calculations (see text).

Table 1. Fraction of population in nursing home by age group: Data versus model (%)

Age group	Data (U.S. Census Bureau, 2020)	Model
65+	2.50	2.63
65–74	0.90	0.81
75–84	2.70	2.74
85–100	10.20	9.50

Notes: This table compares empirical age group-specific prevalence rates of nursing home residency reported by the U.S. Census Bureau (2020) with corresponding shares generated by our population simulation. We model individuals as transitioning stochastically through good health, poor health, nursing home, and death states. The "Model" column reports the simulated proportion of survivors in a nursing home by age band. *Source:* Authors' calculations (see text).

Table 2. Implied annuity loadings (%) at different deferral ages

Age group	M <HS	M HS	M Coll+	F <HS	F HS	F Coll+
Deferral age 67	36.2	28.0	18.9	27.2	15.8	9.5
Deferral age 75	55.5	43.8	30.4	42.4	25.8	15.8
Deferral age 80	68.1	55.4	39.8	53.3	34.1	21.7
Deferral age 85	79.5	67.0	50.6	64.2	43.8	29.2

Notes: This table reports implicit annuity loadings, expressed as percentages of the insurance pricing relative to actuarially fair values. Results are shown separately for females (F) and males (M) in three education groups: college (Coll+), high school (HS), and high school dropouts (<HS). These differences arise because annuitant mortality tables assume lower mortality rates than those estimated empirically. Loadings are lowest for females with a college education, the group with the highest estimated survival probabilities. *Source*: Authors' calculations (see text).

Table 3. Annuitization rates by sex and educational subgroup with/without medical costs and with/without bequest motive (%)

	With bequest		Without bequest	
Subgroup	With health shocks	Without health shocks	With health shocks	Without health shocks
F Coll+	25.7	17.7	28.33	41.1
F HS	8.2	15.6	8.94	52.2
F <HS	2	5.8	2	47.0
M Coll+	11.4	9.5	20.4	39.1
M HS	1.7	5.9	5.7	48.4
M <HS	0.6	1.4	2	49.1

Notes: This table reports the annuitization rates of 401(k) wealth for four different life cycle model specifications: Column 1 refers to our base case with both health state shocks and a bequest motive. Column 2 has no health shocks (medical costs set to zero and mortality determined by sex/education-specific tables only). Column 3 has no bequest motive, and Column 4 has no health shocks and no bequest motive. Results are shown separately for females (F) and males (M) in three education groups: college (Coll+), high school (HS), and high school dropouts (<HS). All scenarios use the identical values at age 66, generated using our baseline model to isolate the effect of bequests and health shocks. *Source*: Authors' calculations (see text).

Table 4. Annuitization rates by sex, education, and annuity type: fixed versus variable payouts across deferral ages

Subgroup	Age 67	Age 75	Age 80	Age 85
Panel A. Fixed annuity				
F Coll+	25.67	20.14	15.04	10.74
F HS	8.25	3.18	1.41	0.92
F <HS	1.89	0.59	0.38	0.23
M Coll+	11.36	9.78	7.27	3.48
M HS	1.67	1.21	0.47	0.26
M <HS	0.59	0.16	0.14	0.08
Panel B. Variable annuity				
F Coll+	35.25	26.36	18.37	11.66
F HS	16.01	6.69	4.07	2.36
F <HS	4.37	1.54	0.85	0.24
M Coll+	20.83	14.25	8.37	6.31
M HS	4.36	1.82	1.14	0.40
M <HS	1.21	0.27	0.14	0.02

Notes: This table reports the percent of 401(k) assets annuitized by deferral age of payout, sex (F = female, M = male), and education subgroup (< HS, HS, Coll +). Panel A ("Fixed annuity") assumes a constant payout, and Panel B ("Variable annuity") assumes benefits linked to a portfolio consisting of a 50/50 stock/bond. All shares are measured at retirement and reflect the optimal trade-off between higher deferred payouts and the probability of survival to the deferral age. Male annuitization rates are lower compared to their female counterparts. *Source*: Authors' calculations (see text).

Table 5. Welfare gains of 401(k) wealth ($000) for annuitization at different deferral ages and for fixed versus variable annuities

Subgroup	Age 67	Age 75	Age 80	Age 85
Panel A. Fixed annuity				
F Coll+	17.185	24.943	**34.345**	30.818
F HS	**3.511**	3.456	2.873	2.384
M Coll+	9.274	11.494	**11.511**	7.449
M HS	**0.709**	0.303	0.111	0.006
Panel B. Variable annuity				
F Coll+	26.359	32.289	**39.613**	33.855
F HS	**7.225**	6.128	4.806	3.674
M Coll+	16.554	**17.614**	16.719	13.086
M HS	**2.300**	1.255	1.317	0.556

Notes: This table reports the welfare gains (in $000) from annuitizing at different deferral ages under fixed versus variable payout annuity contracts. Each entry shows the additional 401(k) wealth a retiree without access to the specified annuity would require at retirement to attain the same lifetime utility as with the annuity. Welfare gains peak at a deferral age of 80 for the Coll+ subgroup under both contract types. HS retirees derive greatest benefit from immediate annuitization. Male gains are substantially lower, reflecting higher mortality and implicit loadings from unisex pricing. Welfare gains for the <HS group are omitted, as their annuity demand is close to zero across deferral age and contract types. Bolded entries indicate the maximum in each row. *Source*: Authors' calculations (see text).

References

Ameriks, J., Caplin, A., Laufer, S., & Van Nieuwerburgh, S. (2011). The joy of giving or assisted living? Using strategic surveys to separate public care aversion from bequest motives. *The Journal of Finance, 66*(2), 519–561. https://doi.org/10.1111/j.1540-6261.2010.01641.x

Arias, E., Xu, J. Q., & Kochanek, K. D. (2023). United States Life Tables, 2021. *National Vital Statistics Reports, 72*(12). National Center for Health Statistics. https://www.cdc.gov/nchs/data/nvsr/nvsr72/nvsr72-12.pdf

Blundell, R., Borella, M., Commault, J., & De Nardi, M. (2024). Old age risks, consumption, and insurance. *American Economic Review, 114*(2), 575–613. https://doi.org/10.1257/aer.20220555

Braun, R. A., Kopecky, K., & Koreshkova, T. (2019). Old, frail, and uninsured: Accounting for features of the US long-term care insurance market. *Econometrica,* 87(3), 981–1019. https://doi.org/10.3982/ECTA15295

Brown, J. R., & Finkelstein, A. (2007). Why is the market for long-term care insurance so small? *Journal of Public Economics, 91*(10), 1967–1991. https://doi.org/10.1016/j.jpubeco.2007.02.010

Brown, J. R., & Warshawsky, M. (2013). The life care annuity: A new empirical examination of an insurance innovation that addresses problems in the markets for life annuities and long-term care insurance. *Journal of Risk and Insurance, 80*(3), 677–704. https://doi.org/10.1111/j.1539-6975.2013.12013.x

Carroll, C. D., & Samwick, A. A. (1997). The nature of precautionary wealth. *Journal of Monetary Economics, 40*(1), 41–71. https://doi.org/10.1016/S0304-3932(97)00036-6

Coy, P. (2023, February 17). The perfect retirement investment nobody wants. *The New York Times*. https://www.nytimes.com/2023/02/17/opinion/retirement-annuity-long-term-care-insurance.html

De Nardi, M., French, E., & Jones, J. B. (2010). Why do the elderly save? The role of medical expenses. *Journal of Political Economy, 118*(1), 39–75. https://doi.org/10.1086/651674

De Nardi, M., French, E., & Jones, J. B. (2016). Medicaid insurance in old age. *American Economic Review, 106*(11), 3480–3520. https://doi.org/10.1257/aer.20140015

De Nardi, M., French, E., Jones, J. B., & McGee, R. (2025). Why do couples and singles save during retirement? Household heterogeneity and its aggregate implications. *Journal of Political Economy, 133*(3), 750–792. https://doi.org/10.1086/733421

Gale, W., Iwry, M., John, D., & Walker, L. (2008). Increasing annuitization in 401(k) plans with automatic trial income. In W. G. Gale, J. M. Iwry, D. C. John, & L. Walker (Eds.), *Automatic: Changing the way America saves* (pp. 123–150). Brookings Institution Press.

Gomes, F. (2020). Portfolio choice over the life cycle: A survey. *Annual Review of Financial Economics, 12*(1), 277–304. https://doi.org/10.1146/annurev-financial-012820-113815

Gomes, F., & Michaelides, A. (2005). Optimal life cycle asset allocation: Understanding the empirical evidence. *Journal of Finance, 60*(2), 869–904. https://doi.org/10.1111/j.1540-6261.2005.00749.x

Gomes, F., Michaelides, A., & Polkovnichenko, V. (2009). Optimal savings with taxable and tax-deferred accounts. *Review of Economic Dynamics, 12*(4), 718–735. https://doi.org/10.1016/j.red.2009.01.004

Gomes, F., Haliassos, M., & Ramadorai, T. (2021). Household finance. *Journal of Economic Literature, 59*(3), 919–1000. https://doi.org/10.1257/jel.20201461

Gong, G., & Webb, A. (2010). Evaluating the advanced life deferred annuity: An annuity people might actually buy. *Insurance: Mathematics and Economics, 46*(1), 210–221. https://doi.org/10.1016/j.insmatheco.2009.08.010

Horneff, V., Love, D. A., & Maurer, R. (2024). Rules of thumb and retirement accounts. *Social Science Research Network (SSRN)*. https://dx.doi.org/10.2139/ssrn.4945939

Horneff, V., Maurer, R., & Mitchell, O. S. (2020). Putting the pension back in 401(k) plans: Optimal versus default longevity income annuities. *Journal of Banking and Finance, 114*(5), 105782. https://doi.org/10.1016/j.jbankfin.2020.105783

Horneff, V., Maurer, R., & Mitchell, O. S. (2023a). Fixed and variable longevity annuities in defined contribution plans: Optimal retirement portfolios taking Social Security into account. *Journal of Risk and Insurance, 90*(4), 831–860. https://doi.org/10.1111/jori.12440

Horneff, V., Maurer, R., & Mitchell, O. S. (2023b). Do required minimum distribution 401(k) rules matter, and for whom? Insights from a lifecycle model. *Journal of Banking and Finance, 154*, 106941. https://doi.org/10.1016/j.jbankfin.2023.106941

Horneff, V., Maurer, R., & Mitchell, O. S. (2025). *Defaulting 401(k) assets into payout annuities for "pretty good" lifetime incomes* (Working Paper 33915). National Bureau of Economic Research. https://doi.org/10.3386/w33915

Hubener, A., Maurer, R, & Mitchell, O. S. (2016). How family status and Social Security claiming options shape optimal life cycle portfolios. *The Review of Financial Studies, 29*(4), 937–978. https://doi.org/10.1093/rfs/hhv070

Investment Company Institute (ICI, 2025). Retirement assets total $43.4 trillion in first quarter 2025. Quarterly Retirement Market Data, First Quarter 2025. Investment Company Institute (https://www.ici.org/system/files/2025-06/ret_25_q1_data.xls)

Internal Revenue Service (IRS, 2014). Longevity annuity contracts. *Federal Register, 79*(127), 37633–37643. www.govinfo.gov/content/pkg/FR-2014-07-02/pdf/FR-2014-07-02.pdf

Internal Revenue Service (IRS, 2021a). Retirement topics – contributions. www.irs.gov/retirement-plans/plan-participant-employee/retirement-topics-contributions

Internal Revenue Service (IRS, 2021b). Your Federal Income Tax 2021 Publication 17. https://www.irs.gov/pub/irs-prior/p17--2021.pdf

Internal Revenue Service (IRS, 2022). Distributions from individual retirement arrangements (IRAs). Publication 590-B. https://www.irs.gov/pub/irs-prior/p590b--2022.pdf

Kephart, J., & Dziubinski, S. (2024, May 15). 3 must-knows before investing in target date funds with annuities. *Morningstar*. https://www.morningstar.com/funds/3-must-knows-before-investing-target-date-funds-with-annuities-2

Kim, H. H., Maurer, R., & Mitchell, O. S. (2016). Time is money: Rational life cycle inertia and the delegation of investment management. *Journal of Financial Economics, 121*(2), 427–447. https://doi.org/10.1016/j.jfineco.2016.03.008

Krueger, P. M., Tran, M. K., Hummer, R. A., & Chang, V. W. (2015). Mortality attributable to low levels of education in the United States. *PlosOne, 10*(7), e0131809. https://doi.org/10.1371/journal.pone.0131809

Love, D. A. (2007). What can the life-cycle model tell us about 401(k) contributions and participation? *Journal of Pension Economics and Finance, 6*(2), 147–185. https://doi.org/10.1017/S1474747206002617

Love, D. A. (2010). The effects of marital status and children on savings and portfolio choice. *The Review of Financial Studies, 23*(1), 385–432. https://doi.org/10.1093/rfs/hhp020

Love, D. A, & Smith, P. A. (2010). Does health affect portfolio choice? *Health Economics, 19*(12), 1441–1460. https://doi.org/10.1002/hec.1562

Medicare.org. (n.d.). *Does Medicaid cover the costs of a nursing home?* www.medicare.org/articles/does-medicaid-cover-the-costs-of-a-nursing-home/

Pang, G., & Warshawsky, M. (2010). Optimizing the equity-bond-annuity portfolio in retirement: The impact of uncertain health expenses. *Insurance: Mathematics and Economics, 46*(1), 198–209. https://doi.org/10.1016/j.insmatheco.2009.08.009

Peijnenburg, K., Nijman, T., & Werker, B. J. (2017). Health cost risk: A potential solution to the annuity puzzle. *The Economic Journal, 127*(603), 1598–1625. https://doi.org/10.1111/ecoj.12354

Samuels, C. (2023). Long-term care statistics: A portrait of Americans in assisted living, nursing homes, and skilled nursing facilities. *A Place for Mom*. https://www.aplaceformom.com/senior-living-data/articles/long-term-care-statistics

Reichling, F., & Smetters, K. (2015). Optimal annuitization with stochastic mortality and correlated medical costs. *American Economic Review, 105*(11), 3273–3320. https://doi.org/10.1257/aer.20131584

Society of Actuaries (SOA, 2012). *2012 Individual Annuity Reserving Table*. Report from the Life Experience Subcommittee of the Joint American Academy of Actuaries/Society of Actuaries Payout Annuity Table Team. Exhibit I. http://www.actuary.org/wp-content/uploads/2025/05/Payout_Annuity_Report_09-28-11.pdf

U.S. Census Bureau (2020). The older population: 2020. https://www2.census.gov/library/publications/decennial/2020/census-briefs/c2020br-07.pdf

Yogo, M. (2016). Portfolio choice in retirement: Health risk and the demand for annuities, housing, and risky stocks. *Journal of Monetary Economics, 80*, 17–34. https://doi.org/10.1016/j.jmoneco.2016.04.008

Appendix A: Technical formulation of the life cycle model

Income, cash on hand, and retirement savings:

During the working life ($t < K$), individuals earn pretax labor income Y_t , which follows a three-state Markov process $\Pi_{ij,t}$, estimated separately by age, sex, and education. Each state incorporates idiosyncratic transitory shocks. The process is identified through wage-rate regressions that decompose earnings into a deterministic trend, a permanent component, and a transitory shock, using PSID data (Appendix Table A.2). Based on these estimates, we simulate the income process for each population subgroup, divide the resulting trajectories into terciles, and compute the corresponding means and standard deviations. These values define the age-specific levels of the discretized Markov income process.

Labor income is subject to federal and state income taxes, Social Security payroll taxes, and Medicare contributions. During retirement ($t \geq K$), retirees receive lifelong Social Security benefits based on their primary insurance amount (PIA). The PIA is calculated as a piecewise linear function of average indexed lifetime earnings, using three marginal replacement rates applied across two bend points: 90% up to the first bend point ($11,952), 32% between the first and second bend points ($72,024), and 15% above the second bend point, up to the 2021 Social Security earnings cap of $142,800. A share of these benefits becomes taxable depending on combined income, with higher earnings subjecting a larger portion of benefits to taxation.

The individual's cash on hand X_t is endogenously allocated toward consumption ($C_t > 0$), investments in stocks ($S_t \geq 0$) and bonds ($B_t \geq 0$), and contributions to a tax-qualified retirement account ($A_t \geq 0$) during work life:

$$X_t = \begin{cases} C_t + S_t + B_t + A_t \,, & t < K \\ C_t + S_t + B_t, & t \geq K \end{cases} \tag{A1}$$

The workers' elective contributions to their retirement accounts are limited to a cap. Additional catch-up contributions are permitted after age 50. The evolution of cash on hand over the period reflects capital returns on risky R_{t+1} and riskless R_f investments, labor income Y_{t+1} net of housing costs $h_{hs,t}$, taxes Tax_{t+1}, withdrawals W_t from the tax-deferred retirement account, and after the deferral period τ, also regular annuity payouts PA_t. Therefore, the balance before the consideration of medical cost is given as follows:

$$X_{t+1}^{-} = \begin{cases} S_t \cdot R_{t+1} + B_t \cdot R_f + Y_{t+1} \cdot \left(1 - h_{hs,t}\right) + W_t - Tax_{t+1}, & t < K \\ S_t \cdot R_{t+1} + B_t \cdot R_f + Y_{t+1} \cdot \left(1 - h_{hs,t}\right) + W_t - Tax_{t+1}, & K \leq t < \tau \\ S_t \cdot R_{t+1} + B_t \cdot R_f + Y_{t+1} \cdot \left(1 - h_{hs,t}\right) + W_t - Tax_{t+1} + PA_t, & t \geq \tau \end{cases} \tag{A2}$$

To account for health-dependent medical expenses $MC_{hs,t}$, cash on hand is reduced by the portion of medical costs not covered by the Medicaid program. We assume that the program protects a minimum level of consumption, specified as $\widetilde{c_t} = \min\,(I_t, \bar{c}_{hs})$, where I_t denotes current after-tax income from Social Security benefits and annuity payouts, and $\bar{c}_{hs}$ represents a health-specific consumption floor. Retirees are required to use any available cash on hand to cover total medical cost. Accordingly, the cash on hand adjusted for medical costs is given by:

$$X_{t+1} = X_{t+1}^{-} - \min\left(X_{t+1}^{-} - \tilde{c}_{t+1}, MC_{hs,t+1}\right). \tag{A3}$$

We follow Gomes and Michaelidis (2005) and model housing expenses as an age-dependent portion of labor income, denoted by $h_{hs,t}$, calibrated in line with Love (2010). Taxes include reduce cash on hand and consist of payroll taxes levied as a fraction of labor income, income taxes according to the U.S. federal tax system, and penalty taxes for early withdrawal from 401(k) accounts (details in the next section).

We assume that elective contributions made from workers' labor incomes to the retirement account are matched by employers' matching contributions, EMC_t, subject to statutory caps. Retirement assets are invested in a target date fund that yields a return of $R_{t+1}^{TDF} = x_t R_{t+1} + (1 - x_t) R_f$, where the portfolio's equity share x_t declines over time according to a predefined glidepath, reflecting the fund's decreasing exposure to equity as the individual ages. Specifically, we assume that the stock exposure declines with age according to the (100-age)/100 rule. At retirement, individuals may annuitize a portion of their accumulated 401(k) balance (DA_K) subject to the IRS-imposed maximum. The remaining account balance continues to generate returns and is gradually depleted through withdrawals in accordance with the RMD rules ($W_t \geq RMD_t$) set by the IRS (2015) starting at age 70.5. The retirement account is partially illiquid, as early withdrawals before age 59.5 are restricted to a maximum of 50% of the account balance. All withdrawals, regardless of timing, are included in taxable income and thus subject to regular income taxation under the U.S. federal tax system. In addition, early withdrawals made before age 59.5 incur a 10% penalty tax, in accordance with U.S. tax regulations. During work life, 401(k) assets evolve according to:

$$L_{t+1} = \begin{cases} (L_t + A_t - W_t + EMC_t) \cdot R_{t+1}^{TDF}, & t < K \\ (L_K - W_K - DA_K) \cdot R_{t+1}^{TDF}, & t = K \end{cases} \tag{A4}$$

If cash on hand is exhausted, retirees are required to make withdrawals from their retirement accounts to cover medical expenses. These forced withdrawals are included in taxable income and are therefore subject to income taxes. Consequently, during retirement, we distinguish the retirement account balance before forced withdrawals for medical cost L_{t+1}^{-} and the balance after such withdrawals L_{t+1}. The former is defined as:

$$L_{t+1}^{-} = (L_t - W_t) \cdot R_{t+1}^{TDF}. \tag{A5}$$

Let MC_{t+1}^{410k} denote the remaining medical cost, after exhausting the cash on hand balance, which is given as follows:

$$MC_{t+1}^{401k} = \max\left\{0, MC_{hs,t+1} - (X_{t+1}^{-} - X_{t+1})\right\} \tag{A6}$$

After accounting for such medical costs, the retirement account balance follows:

$$L_{t+1} = \max\{0, L_{t+1}^{-} - MC_{t+1}^{401k} \cdot (1 + s_{t+1}^{tax})\} \tag{A7}$$

Here, $s_{t+1}^{tax} = IT_{t+1}/Y_{t+1}^{tax}$ denotes the personal income tax rate at time $t+1$.

If cash on hand and retirement savings are not enough to cover medical expenses, the overall transfers by the Medicaid program is given by T^{gov}.

$$T_{t+1}^{gov} = \max\left\{0, MC_{hs,t+1} - [\max(X_{t+1}^{-} - \tilde{c}_{t+1}, 0) + (1 - s_{t+1}^{tax}) L_{t+1}^{-}]\right\}. \tag{A8}$$

This formulation rules out income supplementation. When income falls below $\bar{c}_{hs}$, Medicaid simply pays uncovered medical costs—it doesn't provide direct income transfers to bring individuals up to the health-dependent consumption floor. Importantly, this structure allows for financial recovery in the event of health improvement.

Modeling taxes: Following Horneff et al. (2023a, 2024), we consider the tax treatment for single households having access to a qualified tax-deferred retirement account. In our model, these households pay payroll taxes on labor income ($PayT_t$), federal income taxes (IT_t), and penalty taxes (PT_t) for non-compliant withdrawals from 401(k) accounts. Total taxes, in 2021 dollars, are then given by:

$$Tax_t = PayT_t + IT_t + PT_t\ . \tag{A9}$$

Payroll taxes are proportional to labor income and consist before retirement $t < K$ of Social Security contributions of 6.2% (up to a limit of \$142,800 per year), the Medicare premium of 1.45%, and state and local taxes of 4%. After retirement, Social Security contributions no longer apply, but the other two taxes must still be paid. Overall payroll taxes are given by:

$$PayT_t = \begin{cases} 0.062 \cdot \max(Y_t, 142{,}800) + 0.0545 \cdot Y_t & age < 67 \\ 0.0545 \cdot Y_t & age \geq 67. \end{cases} \tag{A10}$$

Federal income taxes depend on taxable income, which consists of returns on stocks and bonds held in non-tax-qualified accounts, labor income (including Social Security benefits), withdrawals W_t from 401(k) retirement accounts, and annuity payouts starting after the deferral period τ. Elective contributions in 401(k) plans A_t (for $t < K$) are tax-deductible (IRS, 2021a) and subject to a contribution limit of $D_t =$ \$19,500 below age 50 and thereafter $D_t =$ \$26,000. Only a certain proportion of Social Security benefits is taxable depending on the amount of the combined income, which, in our model, equals (positive) returns on stocks, interest from bonds, 401(k) withdrawals, plus half of Social Security benefits. If the combined income is less than \$25,000, benefits are tax-free. If the combined income is between \$25,000 and \$34,000, up to 50% of benefits are taxable. Finally, if combined income is higher than \$34,000, up to 85% of benefits are taxable. In addition, housing cost $h_{hs,t}Y_{t+1}$ (only applicable in health states outside the nursing home) and the portion of medical expenses $MC_{hs,t}$ that exceeds 7.5% of adjusted gross income (AGI) is deductible from taxable income: $MD_t = \max\,(MC_{hs,t} - AGI * 0.075, 0)$. Finally, a general standardized deduction $GD =$ \$12,550 reduces the worker's taxable income if itemized medical expenses and housing cost are lower. Overall taxable income is given by:

$$\begin{aligned} Y_{t+1}^{tax} = \max\big[&\max(S_t(R_{t+1} - 1), 0) + B_t\big(R_f - 1\big) + Y_{t+1} + W_t \\ &+ PA_t - \min(A_t; D_t) - \max\,(GD, h_{hs,t}Y_{t+1} \\ &+ MD_t); 0\big] \end{aligned} \tag{A11}$$

Federal income taxes depend on $i = 1, \ldots, 7$ brackets (IRS, 2021b) defined by a lower and an upper bound of taxable income $Y_{t+1}^{tax} \in [lb_i, ub_i]$ and a marginal tax rate r_i^{tax} given in the following table:

Appendix Table A.1. Federal income tax brackets (in USD)

Bracket number	Lower bound (lb_i)	Upper bound (ub_i)	Marginal tax rate (r_i^{tax})
1	0	9,950	10%
2	9,951	40,525	12%
3	40,526	86,375	22%
4	86,376	164,925	24%
5	164,926	209,425	32%
6	209,426	523,600	35%
7	523,601	and more	37%

Let $TB(Y_{t+1,i}^{tax}) = (Y_{t+1}^{tax} - lb_i) \cdot 1_{\{lb_i \leq Y_{t+1}^{tax} \leq ub_i\}} + (ub_i - lb_i) \cdot 1_{\{Y_{t+1}^{tax} > ub_i\}}$ be the part of taxable income that falls into tax bracket i . Total income taxes are given by:

$$IT_{t+1} = \sum_{i}^{7} TB(Y_{t+1,i}^{tax}) \cdot r_i^{tax} \tag{A12}$$

Finally, early withdrawals from the 401(k) accounts before age 59.5 $(t < 36)$ incur a penalty tax equal to 10% of the withdrawal amount:

$$PT_t = 0.1 \cdot W_t \quad for\ t < 36 \tag{A13}$$

To avoid penalty taxes, 401(k) withdrawals after age 73 must be at least as high as required by the RMD rules set by the IRS.

Appendix Table A.2. Wage rate regression results

Coefficient	Male <HS	Male HS	Male Coll+	Female <HS	Female HS	Female Coll+
Age/100	3.088***	6.231***	9.099***	1.674***	3.280***	6.570***
	(0.198)	(0.112)	(0.186)	(0.212)	(0.0990)	(0.158)
$(\text{Age}/100)^2$	-3.075***	-6.186***	-9.023***	-1.762***	-3.313***	-6.826***
	(0.239)	(0.141)	(0.228)	(0.251)	(0.123)	(0.196)
Constant	2.108***	1.601***	1.330***	2.304***	2.123***	1.828***
	(0.0491)	(0.0233)	(0.0387)	(0.0550)	(0.0209)	(0.0324)
Permanent	0.00709***	0.0102***	0.0137***	0.00750***	0.00917***	0.0145***
	(0.000874)	(0.000506)	(0.000851)	(0.00135)	(0.000501)	(0.000725)
Transitory	0.0314***	0.0331***	0.0471***	0.0249***	0.0299***	0.0356***
	(0.00248)	(0.00136)	(0.00231)	(0.00333)	(0.00138)	(0.00187)
Observations	14,507	60,134	37,645	9,062	57,438	40,221
R^2	0.082	0.150	0.154	0.039	0.062	0.105

Notes: This table reports the regression results for the log wage rates ($2021) using PSID waves 1975–2021 for individuals aged 20–66. Permanent and transitory are decomposed following Carroll and Samwick (1997) and Hubener et al. (2016). The regressions additionally control for part-time and full-time work. Robust standard errors in parentheses. *Source*: Authors' calculations (see text).

Health and survival estimation: We follow a similar estimation strategy as De Nardi et al. (2025) but estimate health transitions and survival probabilities separately by fitting distinct logit models for each process. To ensure that our model accurately captures both the risk of entering a nursing home and the health-dependent variation in mortality, we adjust the regression specification to target the empirical moments of expected remaining lifetimes and the share of retirees residing in nursing homes. The specification that best matches these population-level moments is then applied across all subgroups.

Covering the biennial survey waves from 1992 to 2020, our dataset includes 15 core and exit interviews from the HRS. Our estimation focuses on individuals aged 50 to 100, as the HRS design primarily targets the population over 50 and includes only limited observations for younger individuals, typically as partners of respondents. Thus, because of the low number of observed deaths before age 50, we use survival probabilities for this age range using period life table mortality rates for the year 2021 from Arias et al. (2023), adjusted for sex and education as in Krueger et al. (2015).

To estimate survival probabilities, we construct an indicator variable $alive_{i,t}$ based on the reported year of death in the HRS, identifying whether the respondent is alive in survey year t. We then estimate two-year survival probabilities $\Pr(alive_{t+2} \mid hs_t, age_t)$ by fitting a logit regression model of the form:

$$\Pr\left(alive_{i,t+2} \mid hs_{i,t}, age_{i,t},\right)$$

$$= \frac{\exp\left(\beta_0 + \beta_1 \cdot \left(\frac{Age_{it}}{100}\right)^2 + \beta_2 \cdot hs_{it} + \beta_3 \cdot \left[\left(\frac{Age_{it}}{100}\right)^2 \times hs_{it}\right]\right)}{1 + \exp\left(\beta_0 + \beta_1 \cdot \left(\frac{Age_{it}}{100}\right)^2 + \beta_2 \cdot hs_{it} + \beta_3 \cdot \left[\left(\frac{Age_{it}}{100}\right)^2 \times hs_{it}\right]\right)}. \tag{A14}$$

To obtain annual survival probabilities for the life cycle model, we apply the square root to the estimated two-year probabilities. Appendix Table A.3 reports the corresponding regression results.

For health transitions, we rely on self-reported health status, classified in five categories: excellent, very good, good, fair or poor. We define the "good health" state to include responses of excellent, very good, and good, while fair and poor are grouped into the "poor health" state. Based on the respondents' reported number of nursing home stays, we incorporate a "nursing home" state. Following De Nardi et al. (2025), we classify an individual as residing in a nursing home if they report staying for at least 120 days during the two-year survey interval, or 60 days followed by death before the next interview.

Health transitions are estimated using a multinomial logit model applied to observed transitions in the HRS data. The probability of transitioning from health state h at time t to k at time $t + 2$ follows:

$$\Pr\left(hs_{i,t+2} = k \,\middle|\, hs_{i,t} = h, age_{i,t}\right) =$$

$$\frac{\exp\left(\beta_{0,k} + \beta_{1,k} \cdot \left(\frac{Age_{it}}{100}\right) + \beta_{2,kh} hs_{it}\right)}{\sum_{j\in\{g,p,n\}} \exp\left(\beta_{0,j} + \beta_{1,j} \cdot \left(\frac{Age_{it}}{100}\right) + \beta_{2,j,h} \cdot hs_{it}\right)}. \tag{A15}$$

Resulting regression coefficients are reported in Appendix Table A.4. By applying the matrix square root to the estimated two-year transition matrices, we receive the annual transition probabilities for our life cycle model.

We compute the expected remaining lifetimes starting at age 50 and compare them to the values from the Arias et al. (2023) U.S. life table. In a second step, we simulate a population using the estimated survival and transition probabilities and calculate the fraction of individuals residing in a nursing home. This simulation setup differs from the core life cycle model, in which agents survive deterministically throughout retirement. Similar to Reichling and Smetters (2015), we compare our simulated nursing home prevalence rate to U.S. Census Bureau data from 2020 (see Table 1, main text).

Appendix Table A.3. Logit regression coefficients for survival probabilities

Coefficient	Male <HS	Male HS	Male Coll+	Female <HS	Female HS	Female Coll+	Population
$(\mathrm{Age}/100)^2$	-6.1914***	-6.4385***	-6.9761***	-5.5806***	-7.1495***	-7.2333***	-6.6732***
	(0.2363)	(0.1870)	(0.2529)	(0.2223)	(0.1699)	(0.3016)	(0.0866)
Good health				Base category			
Poor health	-1.7326***	-2.2427***	-3.0522***	-1.3516***	-2.9666***	-2.820***	-2.4906***
	(0.1833)	(0.1414)	(0.2251)	(0.1739)	(0.1366)	(0.2586)	(0.0686)
Nursing home	-3.1465***	-4.1881***	-5.5333***	-5.3748***	-6.5298***	-7.2214***	-5.7344***
	(0.4791)	(0.3896)	(0.6839)	(0.3279)	(0.2911)	(0.6009)	(0.1602)
$(\mathrm{Age}/100)^2 \times$ Good health				Base category			
$(\mathrm{Age}/100)^2 \times$ Poor health	1.3964***	1.6797***	2.4968***	0.8143***	2.8742***	2.2957***	2.1514***
	(0.3036)	(0.2475)	(0.3918)	(0.2713)	(0.2230)	(0.4297)	(0.1141)
$(\mathrm{Age}/100)^2 \times$ Nursing Home	0.5482	1.8784***	3.2887***	3.7878***	5.3503***	6.2007***	4.2816***
	(0.7386)	(0.6234)	(1.0597)	(0.4619)	(0.4106)	(0.8496)	(0.2339)
Constant	5.9143***	6.3543***	6.9954***	5.9645***	7.2894***	7.5412***	6.7497***
	(0.1474)	(0.1104)	(0.1526)	(0.1465)	(0.1086)	(0.1865)	(0.0538)
Observations	25,627	52,420	30,226	35,130	79,337	31,701	254,441
Pseudo R^2	0.1596	0.1803	0.2264	0.1851	0.2274	0.2527	0.2075

Notes: This table reports the regression results from estimating survival probabilities using a logistic specification. The analysis is based on data from the RAND HRS Longitudinal File V1 (2020), covering the years 1992 to 2020 for individuals aged 50 to 100. Estimation conducted separately by sex and education level, as well as for the full sample. *Source*: Authors' calculations (see text).

Appendix Table A.4. Logit regression coefficients for transition probabilities

Outcome	Variable lag	Male <HS	Male HS	Male Coll+	Female <HS	Female HS	Female Coll+	Population
Good health		Base category						
Poor health	Age / 100	0.6739***	1.7776***	3.1752***	0.0069	1.5782***	2.6408***	1.8167***
		(0.1595)	(0.1266)	(0.2088)	(0.132)	(0.0998)	(0.1935)	(0.0554)
	Poor health	2.1973***	2.5933***	3.0693***	2.414***	2.8067***	3.3073***	2.8257***
		(0.0444)	(0.0357)	(0.0595)	(0.0391)	(0.0304)	(0.0592)	(0.0168)
	Nursing home	2.1897***	2.3405***	2.2502***	1.684***	2.2833***	2.56733***	2.2677***
		(0.3208)	(0.2355)	(0.3383)	(0.193)	(0.1434)	(0.2879)	(0.0896)
	Constant	-1.5735***	-3.0020***	-4.5906***	-1.109***	-3.0179***	-4.2985***	-3.0944***
		(0.1123)	(0.0860)	(0.1433)	(0.0958)	(0.0694)	(0.1308)	(0.0383)
Nursing home	Age/100	11.2862***	11.1832***	13.6107***	11.75***	14.0337***	15.5177***	13.3172***
		(0.6431)	(0.6123)	(0.8152)	(0.445)	(0.3836)	(0.7253)	(0.2264)
	Poor health	2.0769***	2.2682***	2.7536***	1.877***	2.3323***	2.5536***	2.3502***
		(0.1163)	(0.1016)	(0.1525)	(0.0820)	(0.0683)	(0.1379)	(0.0394)
	Nursing home	5.854***	6.2536***	5.5985***	4.699***	4.8830***	4.4923***	5.2573***
		(0.3382)	(0.3085)	(0.4187)	(0.203)	(0.1646)	(0.3426)	(0.1065)
	Constant	-12.5449***	-12.9091***	-15.1243***	-12.46***	-14.8276***	-16.2404***	-14.3025***
		(0.5115)	(0.4658)	(0.6356)	(0.363)	(0.3080)	(0.5785)	(0.1798)
Observations		21,043	45,184	26,932	29,638	70,231	28,696	221,724
Pseudo R^2		0.1946	0.2282	0.2572	0.2341	0.2662	0.3031	0.2716

Notes: This table reports the regression results from estimating health transition probabilities using a logistic specification. The analysis is based on data from the RAND HRS Longitudinal File V1 (2020), covering the years 1992 to 2020 for individuals aged 50 to 100. Estimations are conducted separately by sex and education level, as well as for the total population. *Source*: Authors' calculations (see text).

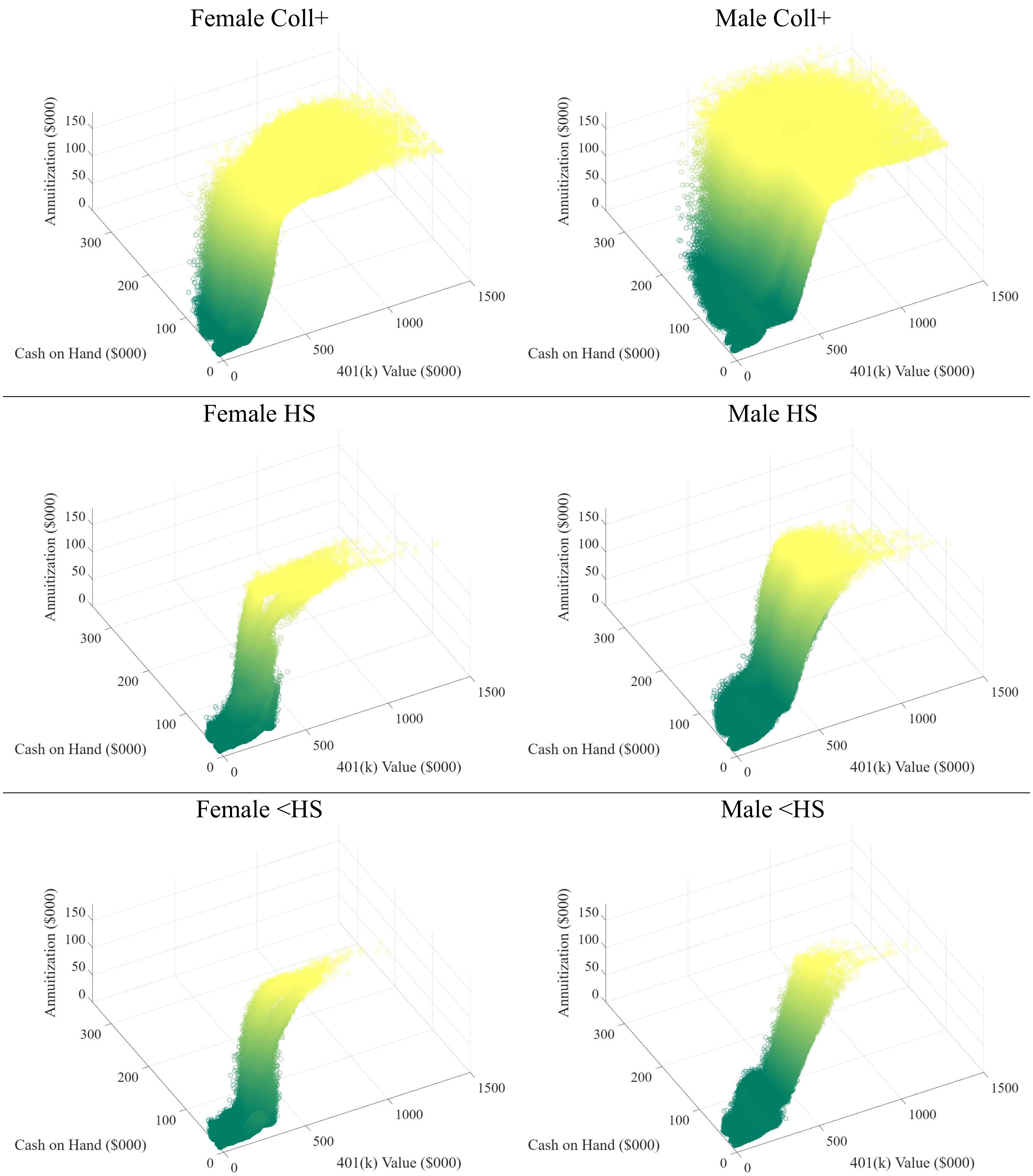
Appendix Table A.5. Model parameterization

Parameter	Variable	Value	Source
Preferences			
Risk aversion	ρ	5	SMM
EIS	ψ	0.2	SMM
Bequest luxury parameter	ϕ	5	SMM
Discount factor	β	0.94	SMM
Bequest strength	b	5	SMM
Assets and income			
Risk-free rate	$R_f - 1$	2%	Typical
Expected return on stock	$E[R_{t+1}] - 1$	6%	Typical
Volatility	σ_r	18%	Typical
Permanent variance		Appendix Table A.2.	Estimation using PSID
Transitory variance		Appendix Table A.2.	Estimation using PSID
Housing	h_t		Love (2010)
Taxes		Appendix A	IRS
Health and survival			
Medical cost	$MC_g/\ MC_p/\ MC_n$	0 / $14,000 / $70,000	Ameriks et al. (2011)
Consumption floor	$\bar{c}_p/\ \bar{c}_n$	$12,880 / $9,528	Poverty line / max SSI benefits
Survival probability	p_t^s	Appendix Table A.3.	Arias et al. (2023); Estimation using HRS
Health transition	H_t	Appendix Table A.4.	Estimation using HRS
401(k) parameters			
Contribution		$19,500 (age<50) $26,000 (age≥50)	IRS limits for 2021
Matching rate		100%	Horneff et al. (2023b)
Matching limit		5% or $14,500	Horneff et al. (2023b)

Notes: This table reports the main parameters along with their values and sources used to solve and simulate our life cycle model.

Appendix B: Further results

Appendix Figure B.1. Annuitization in $000 of 401(k) assets for six sex/education groups



Notes: This figure shows the amount of 401(k) wealth annuitized by sex and education. Each scatter plot displays results from one million simulated individuals, showing their 401(k) balances, cash on hand, and the corresponding dollar amount allocated to immediate annuity purchases. The plots reveal that less-educated individuals tend to have more concentrated distributions below $100,000 in cash on hand and $400,000 in 401(k) assets. Notably, the lower educated are less likely to reach the regulatory annuitization cap. *Source*: Authors' calculations (see text).