Journal of Population Economics (2025) 38:62
https://doi.org/10.1007/s00148-025-01118-y

ORIGINAL PAPER

A life-cycle model of risk-taking on the job

Martin Kerndler[1,2] · **Alexia Prskawetz**[1,3,4] · **Miguel Sánchez-Romero**[1,3,4]

Received: 1 February 2023 / Accepted: 12 July 2025

Abstract

Behavioral studies suggest that individuals become more averse to taking risks as they age. Nevertheless, the incidence of fatal work injuries is increasing in age in the US and the EU. We develop a life-cycle model that rationalizes this pattern. We find that the decreasing value of life incentivizes higher risk-taking towards the end of a career and can potentially dominate an increasing preference for safer jobs. Calibrated to the US, our model generates a compensating wage differential and a trade-off between wealth and mortality, by which wealthier workers give up part of their wages in favor of lower mortality risk at the workplace. In a counterfactual analysis, we study the effect of pension reforms and aging on on-the-job mortality, finding that a higher retirement age as well as lower baseline mortality reduce risk-taking at all ages, while a higher pension replacement rate only benefits older workers.

Keywords Occupational mortality · Compensating wage differentials · Overlapping generations · Value of life

JEL Classification J17 · J28 · J31 · J32 · E13 · E25

Responsible editor: Gregory Ponthiere

✉ Martin Kerndler
martin.kerndler@tuwien.ac.at

Alexia Prskawetz
afp@tuwien.ac.at

Miguel Sánchez-Romero
miguel.sanchez@oeaw.ac.at

1 Institute of Statistics and Mathematical Methods in Economics, TU Wien, Vienna, Austria

2 Economica Institute of Economic Research, Vienna, Austria

3 Vienna Institute of Demography, Wittgenstein Centre for Demography and Global Human Capital (IIASA, OeAW, University of Vienna), Vienna, Austria

4 International Institute for Applied Systems Analysis, Laxenburg, Austria

Published online: 24 July 2025

1 Introduction

Fatal work-related injuries and diseases generate sizable costs for economies. For the United States, Leigh (2011) estimates 58,600 work-related deaths in 2007, accounting for a total economic cost of 52 billion dollars. In the EU28, around 200,000 deaths could be attributed to work-related injuries and diseases in 2017, which amounts to 24% of all deaths in the working population. These implied 3.4 million years of life lost and a loss in output equal to 1.5% of EU GDP (European Agency for Safety and Health at Work 2017a). The output loss increases to 3.3% of GDP if non-fatal diseases and injuries are taken into account as well.[1]

In light of an aging population in many developed countries, it seems critical that the burden of work-related deaths falls on older individuals. This holds both for work-related injuries and work-related diseases. Concerning the latter, Hämäläinen et al. (2007, 2011) find that fatalities attributable to most groups of work-related diseases increase in age.[2] This, however, cannot be taken as evidence whether older workers take more or less risks on the job. In fact, the increasing mortality from work-related diseases could simply reflect that older workers have been exposed longer to the risk factors that cause these diseases, such as asbestos, particulate matter, or long working hours.[3] Additionally, most diseases in the aforementioned groups have long latency periods, such that many years can pass between exposure, outbreak, and death.

More surprising may be the observation that mortality from occupational injuries is increasing in age as well, as is evident in Fig. 1. The bars show the average mortality rates for the years 2011–2018 by age group in the United States and the EU28. Level differences between the US and EU28 are due to the different scope of the underlying numbers provided by the Bureau of Labor Statistics and Eurostat.[4] The age pattern, however, is qualitatively similar in the two regions and shows that the fatality rate starts to increase after age 30 in a convex fashion. In the US, the fatality rate of an average 45–54 (55–64) year old is 23% (53%) higher than the fatality rate of an average 35–44 year old. In the EU, the increase is even steeper.

The increasing age pattern of mortality from fatal injuries is often attributed to the gradual deterioration of physical and mental capacities over the life cycle (Ilmarinen 2008; European Agency for Safety and Health at Work 2016).[5] From a behavioral

[1] Other studies estimate even higher values for selected countries (see Tompa et al. (2021) and references therein).

[2] This holds particularly for malignant neoplasms (cancer), respiratory diseases and circulatory diseases, which together accounted for 92% of fatal work-related diseases in developed countries in 2000 (Hämäläinen et al. 2007).

[3] These represent the main occupational risk factors for fatal diseases identified by World Health Organization and International Labor Organization (2021).

[4] The figures were taken from https://www.bls.gov/iif/oshcfoiarchive.htm and https://ec.europa.eu/eurostat/databrowser/view/HSW_MI01/default/table, respectively. The US numbers relate to all economic sectors while the EU numbers only include agriculture, industry and construction (except mining), and services of the business economy. Furthermore, the US fatality rate is computed per 100,000 full-time equivalent workers, whereas the EU fatality rate is per 100,000 workers.

[5] In Section 2, we conduct a regression analysis to show that this pattern cannot be explained by different occupational and demographic compositions of the age groups, which indeed suggests age as the driving force.

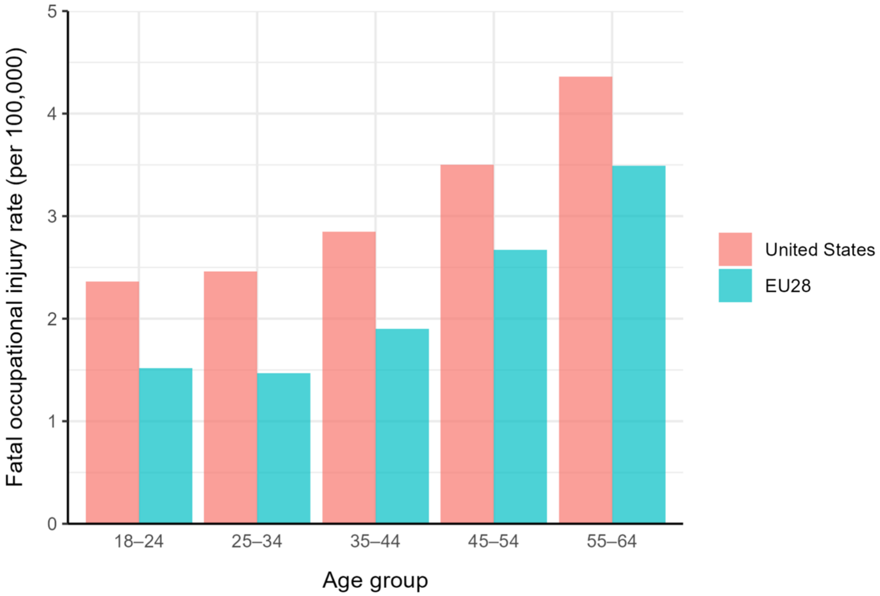


Fig. 1 Average fatality rate by age group in the US and EU28, 2011–2018. Data source: Bureau of Labor Statistics, Eurostat. See text for interpretation

perspective, however, it is not clear why aging individuals do not counteract the increase in mortality risk more strongly. The pattern evident from Fig. 1 indicates that individuals are willing to accept higher mortality risks as they age. This runs counter the widespread evidence that aging individuals become more averse to taking risk throughout all domains (Dohmen et al. 2011; Rolison et al. 2014; Josef et al. 2016).[6] One possible explanation for this apparent contradiction is that workers keep performing the same tasks as they age, not realizing that their diminishing physical and mental abilities have increased the health hazards involved with these tasks. While we cannot rule out a certain degree of misconception of prevailing risks, results from the 2005 European Working Conditions Survey indicate that the share of workers who perceive an impact of work on their health significantly increases in age.[7] This suggests that individuals are aware of the increasing health risks at the workplace, yet do not react sufficiently to counterbalance this, e.g., by reducing risk exposure through working fewer hours or demanding a safer work environment.

Understanding the individual rationales behind this inertia seems of utmost relevance for public policy. Given the observed age gradient in occupational fatalities, the ongoing aging of the workforce and the tendency to delay retirement may increase

[6] An alternative explanation for the observed pattern in Fig. 1 could be that mortality is constant at the individual level and the aggregate age profile results from heterogeneity in mortality rates and selection effects. With only heterogeneity in individual mortality rates, the aggregate age profile would be decreasing, however, since high-mortality individuals die relatively earlier than low-mortality individuals. Since the increase in mortality rate already starts in prime working age, selection of low-mortality individuals into non-employment is also not a convincing explanation.

[7] See Table 10 in European Foundation for the Improvement of Living and Working Conditions (2008).

the prevalence and costs of work-related deaths.[8] To design appropriate policies, it is necessary to understand why older workers take this risk and to what extent risk-taking in later life reflects earlier life-cycle events.

In this paper, we want to stress the role of risk-taking incentives and emphasize that the observed age pattern of work-related mortality from injuries is related to the way these incentives change with age. To this purpose, we develop a dynamic macroeconomic model where individuals endogenously choose the mortality risk experienced on the job over their life cycle. We admit that this is a simplification and several frictions may constrain optimal individual decision-making in practice. For instance, workers may have limited influence over the working conditions of their current job. In the extreme case that a transition to another employer would be necessary to decrease on-the-job mortality risk, workers may increasingly become locked into their current jobs as they age, which could contribute to the observed age pattern. We are convinced, however, that workers can affect their working conditions to some degree since labor market outcomes are ultimately determined by labor demand and labor supply. Indeed, our model is one of few in this strand of the literature that endogenizes both sides of the labor market. Moreover, any frictions one might suggest would always come on top of our mechanism. As long as individuals are rational and forward looking, their incentives follow the same basic intuition as in our model. While we do not neglect the potential relevance of frictions that restrain individual actions in practice, our calibration exercise demonstrates that they are not crucial to match the data.

Our model suggests that two mechanisms contribute to higher risk-taking at older ages. First, reducing mortality risk results in lower wages due to additional costs for the employer. Since wages typically peak late in the career, the wage loss is higher for older workers than for younger workers. Second, the benefit of mortality reduction is related to the individual's value of life, i.e., the discounted sum of expected future utility valued in monetary terms (Murphy and Topel 2006; Kniesner and Viscusi 2019). This corresponds to the value that a worker loses in case of death and decreases in age. Therefore, older individuals experience both higher costs and lower benefits of mortality reductions. Calibrating our model to the US, we are able to explain the observed age pattern of occupational fatality risk almost perfectly, with the decreasing value of life being the main driving force.

Our analysis also explores the role of uninsurable labor income shocks in shaping mortality differentials over the life cycle. We find that at any given age, individuals who have accumulated more wealth are willing to give up part of their current income in exchange for lower on-the-job mortality. The quantitative importance of this mechanism increases in age as individuals want to enter retirement with sufficiently high savings. Finally, we use the calibrated model to study the effect of pension policies and higher life expectancy on on-the-job mortality.

We are not the first to consider work-related mortality in a life-cycle optimization model. In Galama and Van Kippersluis (2019), individuals optimally choose their level of 'job-related health stress'. Higher levels of stress are detrimental to health but compensated by higher wages. In a similar vein, Strulik (2022) analyzes a model

[8] For this reason, strategies to promote occupational health and safety at the workplace are part of the current political agenda (European Commission 2021a, b).

where individuals optimally choose between occupations with low and high health burden, with the latter offering a higher wage. Since both Galama and Van Kippersluis (2019) and Strulik (2022) only focus on labor supply, the monetary compensation for risk-taking is determined by an exogenous wage function. By contrast, in our model, the compensating wage differential is an equilibrium outcome that also takes labor demand into account.

In this aspect, our model is similar to Kerndler (2023), who studies the optimal provision of safety measures in a frictional labor market, where on-the-job mortality and wages are jointly negotiated between the worker and the firm. While we abstract from search frictions, we extend on Kerndler (2023) in many directions. First, we assume a more realistic mortality process and focus on the role of age for mortality. Second, we allow individuals to accumulate wealth, which turns out to be a means to reduce future risk-taking.

We also compare our model results to empirical estimates of compensating wage differentials and the value of a statistical life. The analysis of compensating wage differentials has a long tradition in economics. Rosen (1986) provides a summary of the early literature on compensating differentials. An important related concept is the value of a statistical life (VSL), which was introduced by Thaler and Rosen (1976) and has become an important indicator to evaluate government regulations in the US (Kniesner and Viscusi 2019). The empirical challenges that arise in estimating this value have been summarized by Lavetti (2023). Aldy and Viscusi (2008) and Evans and Schaur (2010) provide age-specific estimates of the VSL, which serve as empirical benchmark for our model outcomes.

Our model offers new insights into the relation between wealth and on-the-job mortality at the individual level. Some recent empirical studies such as Cesarini et al. (2016); Erixson (2017) have investigated the impact of wealth shocks on mortality, without finding a significant effect. In our study, we aim to complement this literature by focusing on the association between wealth and on-the-job mortality, rather than overall mortality, and emphasize the role of age.

The model is also related to the literature that aims at assessing the impact of pension policy reforms on mortality. The literature related to this topic is still scarce and presents mixed results. Some papers indicate that delaying retirement can have negative health impacts, especially in physically demanding jobs (Bellés-Obrero et al. 2022; Abeliansky and Strulik 2023), and others suggest minimal or no significant effects (Hagen 2018; Bozio et al. 2021), or even potential health benefits (Zulkarnain and Rutledge 2018). We complement the empirical studies by providing potential channels through which delaying the retirement age may reduce the risk taken on the job.

The paper proceeds as follows. Section 2 conducts a regression analysis to identify the partial effect of age on the US occupational fatality rate after controlling for potential confounders. Section 3 introduces the behavioral model and characterizes the optimal behavior of individuals and firms as well as the stationary equilibrium. Section 4 presents quantitative results and policy experiments based on a calibration to the US. Section 5 concludes. Additional results and tables are presented in the Supplementary material.

2 Age-specific occupational fatality rates in the US

Before we turn to our behavioral model, we investigate to what extent the age profile in Fig. 1 is driven by differences in the occupational and demographic composition of the age groups. To this reason, we downloaded the number of fatal occupational injuries by age group and detailed occupation from the website of the Bureau of Labor Statistics (BLS).[9] Since 1992, the BLS collects information on all fatal work-related injuries that occur in the United States for its Census of Fatal Occupational Injuries (CFOI). We use the latest public use file of the CFOI, which provides consistent information on fatal occupational injuries from 2011 onward. To reduce selection effects at the beginning and the end of working life, we restrict ourselves to individuals between age 20 and 64. Due to a change in the classification of occupations, we only use data from 2011 to 2018. Our mortality regression is hence based on 880 cells which differ by age group, occupation, and year.[10]

The CFOI by itself does not allow to estimate mortality rates as it does not collect information on the number of workers at risk. Consistent with the recent BLS strategy, we take this information from the Current Population Survey (CPS)[11] and measure the individuals at risk by the number of full-time equivalent workers. This number is constructed from total employment and actual average hours worked. We also use the CPS to collect demographic information at the cell-level. This includes the distribution of sex, race (White, Black, Asian), Hispanics, and education (high school, college) among the working population of each cell. Additionally, we derive the share of self-employed workers, which may account for part of the increase in mortality at later ages (see Pegula 2004). For a robustness check, we also obtain the shares of the five self-assessed health categories (excellent, very good, good, fair, poor) among employed workers from the CPS Annual Social and Economic Supplement (ASEC). The descriptive statistics of the estimation sample are reported in Table A1 in the Supplementary material.

The age profile of mortality is estimated by a Poisson regression at the occupation-year-age group cells, using the number of fatal injuries as dependent variable and the number of full-time equivalent workers as exposure variable. We estimate three specifications, which give rise to the age gradients depicted in Fig. 2. These gradients are obtained by normalizing the age-specific mortality rate estimates by the mortality rate of age group 35–44. The regression model and the construction of these estimates are explained in Supplementary material A.1.

The red dots in Fig. 2 show the age gradient if the mortality rate varies just by age group. This gradient corresponds to the age profile shown in Fig. 1 and indicates that the occupational fatality rate in age group 45–54 (55–64) is 23% (53%) above the fatality rate of age group 35–44. To determine the effect of age-specific differences in employment patterns, the second specification includes occupation fixed effects.

[9] https://download.bls.gov/pub/time.series/fw/

[10] The occupation groups are the 23 two-digit occupations of the SOC 2010 excluding military occupations, which are not covered by the CPS. The 5 age groups are 20–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years.

[11] We use the public microdata files provided by IPUMS (Flood et al. 2021).

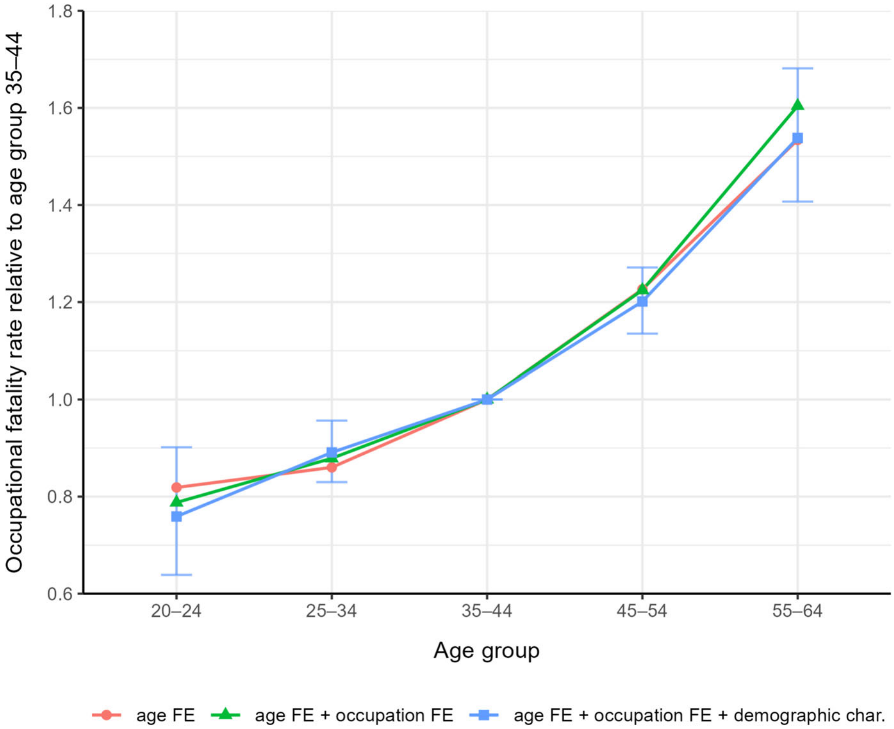


Fig. 2 Estimated age profile of the fatal occupational injury rate for three alternative specifications of the regression model. Notes: Error bars indicate the 95% confidence interval of the point estimate in the full model. See the text for interpretation and Supplementary material A.1 for methodological details

The green triangles show that the age profile becomes slightly steeper in the first and last age group after controlling for occupation. This reflects that on average, younger individuals are employed in more risky occupations, while older individuals are employed in less risky occupations. Holding occupation fixed, mortality increases even faster in age than the average profile in Fig. 1 suggests.

Once we include demographic characteristics among the controls, the gradient reduces again in old age but becomes even steeper at younger ages. This suggests that part of the increasing fatality rate is explained by the fact that sub-populations with an inherently higher mortality are over-represented in early and late working life. The 95% confidence intervals of the point estimates are indicated by the error bars. Except for the two youngest age groups, the confidence intervals do not overlap, such that even after controlling for occupational and demographic composition, the increase in occupational fatality rates over the life cycle is statistically significant.[12]

[12] As a robustness check, we estimate a fourth specification that additionally includes the shares of self-reported health. This set of variables is insignificant and hardly affects the estimated age profile, see column 4 of Table A2. In Section 4.1, the estimated age-mortality profile will be used together with the age-wage profile to calibrate the model. Since the wage data does not include health information, we decided to omit health from our baseline mortality estimates as well.

To rule out that the increasing age pattern is driven by physically demanding low-skilled occupations, we repeat the above analysis separately for low-skilled and high-skilled occupations. These are defined such that the share of college graduates is below or above 50%.[13] The average mortality rate of workers aged 35–44 in the two groups are 4.6 and 0.6 fatalities per 100,000 full-time equivalent workers, respectively. Panel A of Fig. A1 in the Supplementary material shows that the age gradient in the mortality of low-skilled is very similar to the one depicted in Fig. 2. This is not surprising, since almost 90% of all fatal injuries occur in these occupations. Nevertheless, panel B shows that the mortality rate is also significantly increasing in age in high-skilled occupations. The wider error bars are due to the fact that relatively fewer fatalities are observed in these occupations, which increases the uncertainty about the underlying mortality rate.

3 A behavioral model

To understand the increase in occupational fatality rates from injuries over the life cycle, we implement an overlapping generations model with asset accumulation and exogenous retirement. Since all our analysis will focus on the steady state, we omit calendar time from the notation and use t to refer to an individual's age. Our model abstracts from education and occupational choice and is hence reflecting life-cycle patterns that occur within a fixed "average" occupation.[14] The novelty of the model is that employed individuals are confronted with a wage schedule that depends on the mortality risk they are willing to take at the workplace. This wage schedule is determined in general equilibrium together with the interest rate that individuals earn on their assets. Individuals accumulate assets for three purposes. First, they save for retirement because pension benefits only replace part of their previous labor income. Second, individuals have a precautionary savings motive as their labor income is affected by stochastic transitions between employment and unemployment. Finally, we observe that wealth acts as a buffer that allows individuals to reduce on-the-job mortality as their level of consumption is less affected by their current wage.

3.1 Individuals

3.1.1 Mortality and labor market risk

Individuals face two risks: the risk of dying and the risk of becoming unemployed. The risk of dying is compounded by an exogenous mortality risk factor that depends on age t and a factor related to an individual's labor market state $x \in \mathcal{X} = \{\mathcal{L}, \mathcal{U}, \mathcal{R}\}$. In

[13] This cut-off point is suggested by the data as there are no occupations with a share of college graduates between 45 and 70%. "Managerial Occupations" are not considered in this analysis as they both include CEOs and farmers.

[14] To show that the model is also capable of replicating the differences between low-skilled and high-skilled occupations observed in Section 2, we present an extension of the model in Supplementary material A.7. Section 4.2.5 contains selected results based on this extension.

any period of their working life, individuals can be employed ($x = \mathcal{L}$) or unemployed ($x = \mathcal{U}$). At an exogenous age T_R, all individuals switch to retirement ($x = \mathcal{R}$). The conditional survival probability at age t is given by

$$\boldsymbol{\pi}_t(x) = \hat{\pi}_t \cdot \begin{cases} 1 - m_t & \text{for } x = \mathcal{L}, \\ 1 - m_U & \text{for } x = \mathcal{U}, \\ 1 - m_R & \text{for } x = \mathcal{R}, \end{cases} \tag{1}$$

where $\hat{\pi}_t$ denotes the exogenous age-specific baseline survival probability, and m_t, m_U, and m_R denote the additional probabilities of death depending on the labor market status. While m_U and m_R are exogenous, the probability of dying on the job m_t is determined endogenously by the interplay of worker and firm incentives.

Individuals start their lives in unemployment. The transitions between employment and unemployed are stochastic and described by the Markov transition matrix

$$\begin{pmatrix} \mathcal{LL} & \mathcal{UL} \\ \mathcal{LU} & \mathcal{UU} \end{pmatrix} = \begin{pmatrix} 1 - s & p \\ s & 1 - p \end{pmatrix}, \tag{2}$$

where s is the separation probability and p is the job-finding probability. In contrast to the search and matching literature, we treat p as exogenous and assume that wages are determined on a neoclassical labor market. To this purpose, we interpret unemployment as employment with a labor productivity of zero.[15]

All employed individuals provide the same number of working hours to the labor market (which we normalize to one) but differ in their contribution to a firm's output. Drawing on Kerndler (2023), we introduce $y_t(m_t)$ as the net productivity of a worker, which captures productivity after subtracting the costs of risk prevention. Both may depend on the worker's age and his or her exposure to mortality risk at the workplace.

For instance, with increasing age, additional prevention measures may be necessary if mortality risk should remain at a constant level. On the other hand, at any given age, accepting a higher mortality rate lowers prevention costs but may at the same time reduce worker productivity. The potentially nonlinear effect of m_t on net productivity is reflected by the function $y_t(m_t)$ as stated in Assumption 1.[16]

Assumption 1 *For $m_t \in [0,1]$, net productivity $y_t(m_t)$ is non-negative, twice continuously differentiable and for some $\tilde{m}_t \in (0,1]$ satisfies that $y_t'(m_t) > 0$ and $y_t''(m_t) < 0$ for $m_t < \tilde{m}_t$, while $y_t'(m_t) < 0$ for $m_t > \tilde{m}_t$.*

Assumption 1 supports two functional forms that are empirically plausible and bear simple economic interpretation. First, $y_t(m_t)$ could be strictly increasing and strictly concave on its entire domain, which corresponds to $\tilde{m}_t = 1$. This reflects that reducing mortality comes at a cost, e.g., because adhering to safety procedures and wearing safety gear slow down the worker or because regular maintenance of machines interrupt production. Furthermore, concavity implies that a small reduction

[15] Kerndler (2023) studies endogenous on-the-job mortality risk in a labor market with search frictions.

[16] The assumed properties mimic the shape restrictions introduced in Assumption 1 of Kerndler (2023) and guarantee uniqueness of the equilibrium.

in mortality can be achieved relatively cheaply (for instance by wearing hard hats on a construction site), while larger reductions become disproportionally more expensive.

A second possibility for $y_t(m_t)$ supported by Assumption 1 is a unimodal shape, where net productivity increases in mortality only up to some $\tilde{m}_t \in (0,1)$ and then reduces again. This could capture that workers who face excessive mortality rates may also have more absences due to non-fatal injuries, try to avoid their workplace (absenteeism), or exert lower effort while present.[17]

3.1.2 Optimal individual decisions

Irrespective of their labor market state, individuals face a consumption-saving decision. Employed individuals additionally decide on their level of on-the-job mortality m_t. The maximized expected utility W_t of an individual at age t with assets a_t in labor market state $x \in \mathcal{X}$ satisfies the Bellman equation

$$W_t(a_t, x) = U(c_t|x) - \mathbf{1}_{\{x=\mathcal{L}\}}\chi(1 - \boldsymbol{\pi}_t(x)) + \beta\boldsymbol{\pi}_t(x)\mathbf{E}_t\left[W_{t+1}(a_{t+1}, x')|x\right], \quad (3)$$

where $U(c)$ is a standard period utility function (with $U(c) > 0$, $U'(c) > 0$, and $U''(c) < 0$) that depends on consumption c. Since every working individual inelastically provides one unit of labor, there is no disutility from the intensive margin of labor supply. However, individuals may experience disutility of work from the extensive margin, which is related to their mortality. This disutility is weighted by $\chi \geq 0$ and linearly depends on the individual's conditional mortality rate $1 - \boldsymbol{\pi}_t(x)$ with $\boldsymbol{\pi}_t(x)$ given in Eq. 1. Since older individuals exhibit a higher baseline mortality, they experience a higher disutility of work for any given on-the-job mortality m_t. The continuation value is discounted with the subjective discount factor $\beta \in [0,1]$ and the conditional survival probability $\boldsymbol{\pi}_t(x)$.

Consumption-saving decision Individuals choose their consumption c to maximize (3) subject to the state-dependent asset dynamics

$$a_{t+1}|x = \begin{cases} \frac{R}{\boldsymbol{\pi}_t(x)}(a_t + (1-\tau)w_t(m_t) - c_t) & \text{for } x = \mathcal{L}, \\ \frac{R}{\boldsymbol{\pi}_t(x)}(a_t + z_t - c_t) & \text{for } x = \mathcal{U}, \mathcal{R}. \end{cases} \quad (4)$$

The wage income of employed individuals, $w_t(m_t)$, depends on their on-the-job mortality and is taxed at rate τ. The wage function is determined on the labor market and beyond the worker's influence. Unemployed and retired individuals receive an age-dependent transfer z_t from the government. For $t < T_R$, we interpret z_t as unemployment benefits and for $t \geq T_R$ as pension benefits. The gross interest rate R is determined on the capital market. We assume an annuity market which equally distributes the wealth of deceased individuals among the survivors with the same characteristics. The effective gross interest rate on savings is therefore $R/\boldsymbol{\pi}_t(x)$ and assumed to be beyond the influence of the individual.

[17] An ever decreasing function, which would correspond to $\tilde{m}_t = 0$, does not seem empirically plausible, as completely eliminating on-the-job mortality would require substantial costs.

It is straightforward to obtain the first-order condition for consumption, $U'(c_t|x) = R\beta\mathbf{E}_t\left[W'_{t+1}(a_{t+1}, x')|x\right]$, as well as the envelope condition, $W'_t(a_t, x) = R\beta\mathbf{E}_t\left[W'_{t+1}(a_{t+1}, x')|x\right]$. Combining the two equations yields the consumption Euler equation

$$U'(c_t|x) = R\beta\mathbf{E}_t\left[U'(c_{t+1}|x')|x\right], \tag{5}$$

which together with the asset dynamics (4) determines optimal consumption growth.

Optimal level of on-the-job mortality Employed individuals additionally choose how much mortality risk they are willing to take on the job. Applying the envelope theorem, the fist-order condition with respect to m_t is

$$\chi\hat{\pi}_t + \beta\hat{\pi}_t\mathbf{E}_t\left[W_{t+1}(a_{t+1}, x')|\mathcal{L}\right] = U'(c_t|\mathcal{L})(1-\tau)w'_t(m_t). \tag{6}$$

The left-hand side of Eq. 6 reflects the marginal cost of higher mortality. The first term is the immediate cost accruing from a higher disutility of work, while the second term is the discounted sum of expected utility lost by dying earlier. The right-hand side of Eq. 6 reflects the marginal gain of higher on-the-job mortality. As will become clear below, firms in equilibrium are willing to reward higher risk-taking with higher wages. Therefore, a marginally higher on-the-job mortality increases a worker's wage, $w'_t(m_t) > 0$, and thereby utility from consumption.

To gain further intuition about the optimal level of on-the-job mortality, it is convenient to define the value of life of a worker as $\mathrm{VoL}_{t|\mathcal{L}} = \mathbf{E}_t\left[W_{t+1}(a_{t+1}, x')|\mathcal{L}\right]/U'(c_t|\mathcal{L})$. The value of life converts the lifetime utility, which is measured in "utils," into monetary equivalent units, compare (Murphy and Topel 2006). Dividing both sides of Eq. 6 by $U'(c_t|\mathcal{L})$ and using the newly defined variable gives

$$(1-\tau)w'_t(m_t) = \hat{\pi}_t\left[\frac{\chi}{U'(c_t|\mathcal{L})} + \beta\mathrm{VoL}_{t|\mathcal{L}}\right]. \tag{7}$$

Equation 7 states that the optimal on-the-job mortality rate of an individual satisfies that the marginal gain in wage income equals the monetized increase in the disutility of work plus the monetary value lost through dying earlier, multiplied by the baseline survival probability, $\hat{\pi}_t$. While the latter variable is decreasing in age, the evolution of the term in square brackets in Eq. 7 is less clear. If consumption is increasing throughout working life, the monetized disutility of work rises as well and incentivizes lower risk-taking on the job with increasing age. At the same time, the shorter remaining lifetime reduces an individual's value of life, which increases their willingness to take risk as they age.

3.2 Firms

There is a representative firm that uses effective labor and capital to produce the single output good according to a neoclassical production function $F(K, H)$. Labor services of different individuals are assumed to be perfect substitutes in production such that effective labor is

$$H = \sum_{t=0}^{T_R-1} \int y_t(m_t) L_t(m_t)\, dm_t, \tag{8}$$

where $y_t(m_t)$ is the net productivity of an age t individual with on-the-job mortality m_t introduced in Assumption 1, and $L_t(m_t)$ denotes the mass of individuals with these characteristics employed by the firm. The firm maximizes its profit

$$F(K, H) - rK - \sum_{t=0}^{T_R-1} \int w_t(m_t) L_t(m_t)\, dm_t$$

with respect to $L_t(m_t)$ and K, where $w_t(m_t)$ is the wage paid to an age t worker whose on-the-job mortality is m_t. The first-order conditions of the firm's profit maximizing problem are

$$w_t(m_t) = F_H(K, H) y_t(m_t), \tag{9}$$

$$r = F_K(K, H). \tag{10}$$

Equation 9 holds for any age $t \in \{0, \ldots, T_R-1\}$ and on-the-job mortality m_t and states that a worker's wage is proportional to her net productivity. Assuming that F exhibits constant returns to scale, the firm in optimum earns zero profit and is indifferent to the size and composition of its workforce. Furthermore, Eq. 10 pins down the optimal ratio between capital and labor inputs, K/H.

3.3 Equilibrium

Sections 3.1 to 3.2 describe the optimal behavior of firms and workers. We now formulate the additional conditions that have to hold in a stationary equilibrium of our model.

3.3.1 Capital market

Capital used in production corresponds to aggregate individual savings,

$$K = \sum_{t=0}^{\infty} \int a_t N_t(a_t)\, da_t, \tag{11}$$

where $N_t(a_t)$ is the mass of age t individuals holding assets worth a_t. The real interest rate r that clears the capital market satisfies (10). Assuming that capital depreciates with a rate of $\delta \geq 0$ per period, the gross return on savings in Eq. 4 equals $R = 1+r-\delta$.

3.3.2 Labor market

Substituting the wage function (9) into (7) reveals that the on-the-job mortality of a worker in equilibrium satisfies

$$y_t'(m_t) = \frac{\hat{\pi}_t}{F_H(K,H)(1-\tau)} \left[\frac{\chi}{U'(c_t|\mathcal{L})} + \beta \mathrm{VoL}_{t|\mathcal{L}} \right], \tag{12}$$

where H and K are given in Eqs. 8 and 11, respectively. Provided that $\chi \geq 0$ and $\mathrm{VoL}_{t|\mathcal{L}} > 0$, the right-hand side of Eq. 12 is strictly positive and therefore $y_t'(m_t) > 0$ in equilibrium. By Assumption 1, this implies $y_t''(m_t) < 0$, such that the left-hand side of Eq. 12 is strictly decreasing in m_t. Since the right-hand side is increasing, the equilibrium on-the-job mortality is unique and lies on the upward sloping part of the net productivity function.[18]

Because workers are perfect substitutes, the mass of workers of each type demanded by the firm, $L_t(m_t)$, equals the mass of individuals with these characteristics in the employable population (i.e., all individuals with labor market state $x \in \mathcal{L}$). We can therefore define the mass of employed individuals of age t as $L_t = \int L_t(m_t)\, dm_t$, and the mass of unemployed individuals of age t as the mass of all currently unproductive individuals (i.e., all individuals with labor market state $x \in \mathcal{U}$). According to Eqs. 1 and 2, the mass of employed and unemployed individuals evolve according to

$$\begin{pmatrix} L_{t+1} \\ U_{t+1} \end{pmatrix} = \begin{pmatrix} 1-s & p \\ s & 1-p \end{pmatrix} \begin{pmatrix} \overline{\boldsymbol{\pi}}_t(\mathcal{L}) & 0 \\ 0 & \boldsymbol{\pi}_t(\mathcal{U}) \end{pmatrix} \begin{pmatrix} L_t \\ U_t \end{pmatrix}$$

for ages $t = 0, \ldots, T_R - 2$, where $\overline{\boldsymbol{\pi}}_t(\mathcal{L}) = \hat{\pi}_t \int (1-m_t) \frac{L_t(m_t)}{L_t}\, dm_t$ is the average conditional survival probability of employed individuals at age t.

Every individual starts out without a job, implying $L_0 = 0$ and $U_0 = N_0$, where $N_0 > 0$ is the exogenously given mass of newborns. Since everybody retires at age T_R, the mass of retired workers satisfies

$$R_t = \begin{cases} 0 & \text{for } t < T_R, \\ \overline{\boldsymbol{\pi}}_{t-1}(\mathcal{L}) L_{t-1} + \boldsymbol{\pi}_{t-1}(\mathcal{U}) U_{t-1} & \text{for } t = T_R, \\ \boldsymbol{\pi}_{t-1}(\mathcal{R}) R_{t-1} & \text{for } t > T_R. \end{cases}$$

3.3.3 Government budget

The government collects wage taxes from all working individuals to finance transfers z_t to the unemployed and retired population. The tax rate τ is set to balance the budget,

$$\sum_{t=0}^{T_R-1} \int \tau w_t(m_t) L_t(m_t)\, dm_t = \sum_{t=0}^{T_R-1} z_t U_t + \sum_{t=T_R}^{\infty} z_t R_t,$$

[18] The level of m_t affects the right-hand side of Eq. 12 only indirectly via c_t. Since a higher m_t in equilibrium leads to a higher net productivity and therefore a higher wage, c_t and a_{t+1} both increase. Therefore, $\frac{1}{U'(c_t|\mathcal{L})}$ increases and so does expected future utility. As a consequence, $\mathrm{VoL}_{t|\mathcal{L}}$ is an increasing function of m_t.

where for $t < T_R$, we interpret z_t as unemployment benefits and for $t \geq T_R$ as pension benefits.

3.4 Qualitative analysis

As the equilibrium on-the-job mortality is our main model outcome, this section presents a graphical comparative static analysis of this variable. This exercise also makes the factors that affect the age profile of on-the-job mortality more transparent, which facilitates the interpretation of our quantitative analysis in Section 4.

To simplify the graphical representation, we rewrite the equilibrium condition (12), recalling (9), in the form

$$\frac{y_t'(m_t)}{y_t(m_t)} = \frac{\hat{\pi}_t}{(1-\tau)w_t(m_t)}\left[\frac{\chi}{U'(c_t|\mathcal{L})} + \beta \mathrm{VoL}_{t|\mathcal{L}}\right]. \tag{13}$$

The left-hand side of Eq. 13 measures the marginal benefit of higher mortality in terms of the relative change in the worker's net productivity. The right-hand side captures the marginal cost, expressed as monetized utility loss from higher mortality (compare the discussion following (7)) relative to the worker's net wage.

Net productivity For didactic reasons, we at this point introduce the net production function that is later used in the quantitative analysis of Section 4 as

$$y_t(m_t) = \overline{y}_t m_t^{\sigma_y} e^{-\lambda m_t} \tag{14}$$

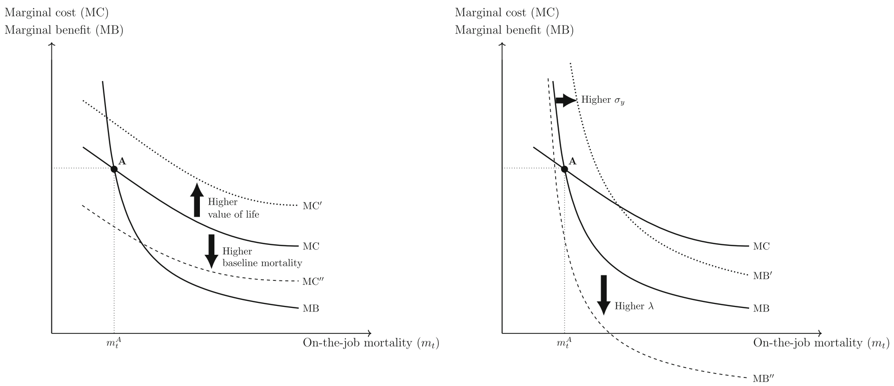
where $\sigma_y \in (0,1)$ and $\lambda \geq 0$. While $\overline{y}_t$ is exogenous, the remaining two terms depend on m_t. The term $m_t^{\sigma_y}$ captures the effect of m_t on net productivity by reducing prevention costs. In particular, a 1% increase in the mortality rate is assumed to increase net productivity by σ_y% through this channel. At the same time, the higher mortality may reduce worker productivity due to more frequent absences or reduced work effort. This is captured by the term $e^{-\lambda m_t}$. The parameter λ measures the relative reduction in productivity that occurs for every increase in m_t by one unit. In the quantitative section, λ will be identified as the fraction of working time lost due to non-fatal occupational injuries and diseases relative to the number of fatal injuries.

Besides its intuitive nature, the functional form (14) is supported by empirical evidence. In particular, the age-specific VSL estimates of Aldy and Viscusi (2008) suggest that the increase in log-wages paid to compensate the worker for higher mortality rises linearly in $\frac{1}{m_t}$. As demonstrated in Supplementary material A.5, this property is satisfied by Eq. 14.

Substituting (14) into (13), the left-hand side becomes

$$\frac{y_t'(m_t)}{y_t(m_t)} = \frac{\sigma_y}{m_t} - \lambda. \tag{15}$$

This makes apparent that Eq. 14 supports the two shapes of $y_t(m_t)$ allowed by Assumption 1. For $\lambda = 0$, higher mortality does not have any detrimental effect on



(A) Change in marginal cost (MC) (B) Change in marginal benefit (MB)

Fig. 3 Stylized illustration of the equilibrium on-the-job mortality and its response to *ceteris paribus* changes in the marginal cost (**A**) and marginal benefit (**B**)

(gross) productivity and $y_t(m_t) = \overline{y}_t m_t^{\sigma_y}$ is monotonically increasing and concave. Furthermore, $\overline{y}_t$ represents the maximum attainable net productivity of the worker, realized when $m_t = 1$. With $\lambda > 0$, Eq. 15 reveals that net productivity peaks at $\tilde{m}_t = \frac{\sigma_y}{\lambda}$. For $\lambda \in (0, \sigma_y]$, the function is still concave and monotonic on $[0,1]$, while it becomes unimodal for $\lambda > \sigma_y$. In this case, the positive effect of lower prevention costs is outweighed by the negative productivity effect beyond $\tilde{m}$, such that net productivity starts to fall.[19]

Graphical analysis Figure 3 illustrates how the equilibrium on-the-job mortality responds to *ceteris paribus* changes in its determinants. Both panels depict the equilibrium mortality m_t^A that results from the intersection of the marginal benefit curve (MB) given in Eq. 15 and the marginal cost curve (MC), which corresponds to the right-hand side of Eq. 13.

As shown in Fig. 3A, a higher value of life, $\text{VoL}_{t|\mathcal{L}}$, shifts the marginal cost curve upwards (MC'), resulting in an equilibrium with lower on-the-job mortality. A higher baseline mortality, on the other hand, reduces $\hat{\pi}_t$ and shifts the marginal cost curve downwards (MC"), resulting in a higher on-the-job mortality. The same happens after a *ceteris paribus* increase of the current net wage $(1 - \tau)w_t(m_t)$.

Ceteris paribus changes in the parameters of the net production function shift the marginal benefit curve. As depicted in Fig. 3B, a higher elasticity σ_y shifts the curve upwards (MB'), leading to a higher equilibrium on-the-job mortality. A higher sensitivity of productivity to mortality as captured by λ, by contrast, reduces the marginal benefit (MB") and lowers on-the-job mortality in equilibrium.

The effect of age Figure 3 also allows to infer how the equilibrium on-the-job mortality changes in age. Equation 15 reveals that the marginal benefit curve is independent of age. The marginal cost curve, by contrast, depends on age via four channels. First,

19 It is straightforward to show that $y_t(m_t)$ is concave until it reaches an inflection point at $\frac{\sigma_y+\sqrt{\sigma_y}}{\lambda} > \tilde{m}_t$. Therefore, Assumption 1 is indeed satisfied.

the baseline mortality increases in age. Second, the value of life is likely to decrease in age as the expected remaining lifetime shortens (Murphy and Topel 2006). Both effects push the MC curve downwards and tend to increase on-the-job mortality with age. Thirdly, there is a wage channel. As long as wages increase in age (for given m_t), this results in an additional downward shift of MC. In the data, however, wages begin to fall in late working life, such that eventually the wage channel acts dampening on on-the-job mortality. If $\chi > 0$, there is a fourth channel, which incentivizes to reduce on-the-job mortality with age provided that consumption is increasing during working life. The quantitative importance of these channels is explored in the next section.

4 Quantitative analysis

In this section, we assess the quantitative importance of the four theoretical channels that affect the age-profile of on-the-job mortality as identified in Section 3.4. Additionally, we investigate the joint distribution of age, wage, on-the-job mortality, and wealth generated by the model. In line with the empirical literature, our model generates compensating wage differentials that decrease in age. Furthermore, we find that wealth plays an important role in dampening the increase in on-the-job mortality, especially at later ages. Finally, we discuss the effect of pension reforms and aging on risk-taking on the job.

4.1 Calibration

We calibrate the stationary equilibrium to the US with a model period corresponding to 1 month. All individuals start their economic life at age 20 ($t = 0$) and retire at age 65 ($T_R = 540$). We set the subjective discount rate of households to zero, $\beta = 1$, which is a standard assumption in models in which there is an objective discount factor (see for instance Lee et al. (2000); Boucekkine et al. (2002); Sánchez-Romero et al. (2013)). Household utility is of the CRRA form,

$$U(c) = \begin{cases} \dfrac{c^{1-1/\sigma_C} - 1}{1 - 1/\sigma_C} & \text{for } \sigma_C > 0,\ \sigma_C \neq 1, \\ \log(c) & \text{for } \sigma_C = 1, \end{cases}$$

where σ_C is the elasticity of intertemporal substitution. Concerning disutility of work, we observe that an increase in χ results in a flattening of the age gradient of on-the-job mortality. Since the profile obtained using $\chi = 0$ is already slightly flatter than what we observe in the data, we set $\chi = 0$.

The baseline age-specific survival probability $\hat{\pi}_t$ follows a Gompertz law, i.e., $\hat{\pi}_t = \exp(-\alpha_\pi \exp(\beta_\pi (\frac{t}{12} + 20)))$. We choose $\alpha_\pi = e^{-9.63}$ and $\beta_\pi = 0.08185$, which allows us to match the observed life expectancy at age 20 in the year 2015 reported by the Human Mortality Database (2023) for the US.[20] The conditional probability

[20] Just considering the baseline mortality, the life expectancy at age 20 would be 60.3 years.

of dying during unemployment is $m_U = 1 - 0.993^{1/12}$, reflecting empirical studies that mortality is higher for unemployed than for employed individuals (Gerdtham and Johannesson 2003; Eliason and Storrie 2009; Sullivan and von Wachter 2009; Paglione et al. 2020).[21] To prevent that overall mortality decreases once individuals retire, we assume $m_R = sm_U + (1-s)[1 - \exp(-4.5 \times 10^{-5}/12)]$. This is the weighted average between the conditional mortality of an unemployed worker and the on-the-job mortality of an employed worker aged 55–65 as observed in the data. The labor market transition rates are taken from Shimer (2005), who reports a separation probability of $s = 0.034$ and a job-finding probability of $p = 0.45$.

The government transfers z_t are tied to labor income. For $t < T_R$, the transfer represents unemployment benefits, which we assume to replace a share ϕ_U of average wage income of all workers of the same age as the recipient. For $t \geq T_R$, agents receive pension benefits equal to a share ϕ_R of the average wage income earned by all workers in the economy. In our benchmark calibration, $\phi_U = \phi_R = 0.4$, reflecting features of the US welfare system.

The aggregate production function is Cobb-Douglas, $F(K, H) = K^{\alpha} H^{1-\alpha}$ with $\alpha = 0.33$. Capital depreciates at an annual rate of 5%, such that $\delta = 1.05^{1/12} - 1$. The net productivity of a worker is specified as in Eq. 14, with $\overline{y}_t = \overline{y} f(t)$ where $\overline{y} > 0$ and $f(t)$ is the exogenous age-profile of productivity.[22] For given σ_y and λ, the shape of $f(t)$ can be inferred from the empirical age profiles of wages and mortality by noting that Eqs. 9, 14, and $\overline{y}_t = \overline{y} f(t)$ imply

$$\frac{f(t)}{f(s)} = \frac{w_t(m_t)}{w_s(m_s)} \left(\frac{m_s}{m_t}\right)^{\sigma_y} e^{\lambda(m_t - m_s)} \tag{16}$$

for any working ages s and t. In Fig. 2, we have already estimated the age profile of work-related mortality. To estimate the wage profile, we use the outgoing rotation group data of the CPS from 2011 to 2018. First, an hourly wage measure is constructed by dividing weekly earnings by average working hours. This is regressed on dummies for age, sex, race, Hispanic origin, education, two-digit occupation, and year.[23] The estimated age-fixed effects are then averaged to the age group level and used together with the mortality rates estimated in Section 2 to evaluate the right-hand side of Eq. 16. Finally, we normalize $f(s) = 1$ for age group 35–44 and fit a quadratic polynomial in age through the five data points to obtain a smooth function $f(t) = f_0 + f_1 t + f_2 t^2$.

The parameter λ is estimated from data on work absences. Our main source is the Survey of Occupational Injuries and Illnesses (SOII) conducted by the BLS. The SOII captures non-fatal work-related injuries or illnesses that require medical care beyond first aid. These incidences can lead to one or more days away from work, days with reduced working capacity (eventually being assigned a different job) or have no longer-lasting effects. Using the SOII data from 2011 to 2018 gives rise to $\lambda = 612.84$.

[21] Our sensitivity checks show that the numerical results are robust to different choices of m_U.

[22] Our multiplicative specification of $y_t(m_t)$ implies that the compensation for risk-taking, $w_t'(m_t)$, is proportional to the worker's wage $w_t(m_t)$. This is in line with empirical studies that estimate an income elasticity of the value of a statistical life of around 1 (Bellavance et al. 2009; Hammitt et al. 2022).

[23] We again use the IPUMS version of the CPS (Flood et al. 2021). The categories of the explanatory variables are the same as considered in Section 2.

The detailed estimation process is explained in Supplementary material A.6, where we also conduct several robustness checks. Relying on the SOII to estimate λ has two limitations. First, since the numbers are based on employer interviews, some degree of underreporting may occur. Second, more absence days due to non-fatal incidences are only one potential channel through which higher on-the-job mortality reduces worker productivity. As a robustness check, we derive λ from CPS data on total work absences, which results in quantitatively similar model outcomes. We also conducted further robustness checks that account for additional costs of work injuries, such as medical expenses and legal costs. These confirm that the quantitative results presented in this section are robust to a wide range of cost estimates.

The parameters $\overline{y}$, σ_y, and σ_C are jointly calibrated. Since the productivity level $\overline{y}$ has a direct effect on wages by Eq. 9, it is set such that the wage in age group 35–44 equals the average monthly wage of this age group in the CPS. All monetary values are expressed in 2015 dollars. The remaining parameters σ_y and σ_C are chosen to match (i) the average occupational fatality rate of the CFOI/CPS data and (ii) an average value of life of 12 million dollars as estimated by Kniesner and Viscusi (2019).[24] The age-profile of mortality is not targeted in our calibration but serves to validate the model outcomes.

The calibrated parameters are reported in Table 1. The intertemporal elasticity of substitution $\sigma_C = 0.8685$ lies in the empirically plausible range and implies that consumption increases over the life cycle at a rate of 1% per year. This is in line with the National Transfer Account profiles of private consumption excluding health expenditures, which exhibit growth rates between 0 and 1% in the US.[25] The calibrated value of $\sigma_y = 0.0145$ implies that a one percent reduction in mortality lowers worker productivity by 0.0129%. The calibrated age-productivity profile $f(t)$ is hump-shaped and peaks around age 50. The tax rate that balances the government budget is $\tau = 0.1976$, and the equilibrium interest rate is 1.69% annually.[26]

4.2 Simulation results

The results shown below are based on a simulated monthly population consisting of 500 agents. To ensure that economic aggregates are independent of the simulation sample size, the population size is normalized to 1000 in the computations. These are ex ante identical agents born without wealth. Due to unemployment risk as well as mortality risk, they become increasingly heterogeneous over time.

In Sections 4.2.1 to 4.2.3, we highlight important features of the marginal and joint distributions of age, wages, on-the-job mortality, and wealth, generated by the

[24] Kniesner and Viscusi (2019) in fact estimate the value of a statistical life (VSL), which captures the willingness of workers to pay for a reduction in mortality by one death per 100,000 workers. Replicating their estimations on simulated wage and mortality data from our model, we find that the VSL comes close to the value of life VoL (see also Table 2).

[25] See https://www.ntaccounts.org for the full database and Lee and Mason (2011) for documentation.

[26] The social contribution tax rate implied by the model exceeds actual US levels. The reason is that for simplicity, we assume a stationary model population, while the US population grows at a rate close to 1% per year. Taking this into account, the equilibrium tax rate would drop to $\tau = 0.14$.

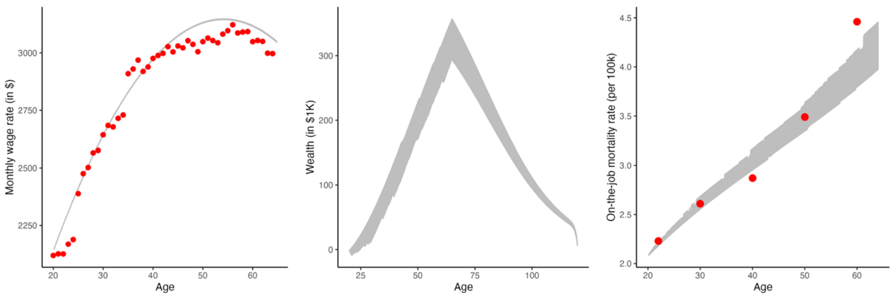
Table 1 Overview of the parameter values for the benchmark run

Parameter	Symbol	Value
(a) Externally set parameters		
Subjective discount factor	β	1
Disutility of work	χ	0
Duration of working life (months)	T_R	540
Gompertz law for baseline mortality	α_π, β_π	$e^{-9.63}$, 0.08185
Conditional mortality in unemployment	m_U	$1 - 0.993^{1/12}$
Conditional mortality in retirement	m_R	$sm_U + (1-s)[1 - e^{-4.5\times 10^{-5}/12}]$
Job separation probability	s	0.0340
Job finding probability	p	0.4500
Unemployment benefit replacement rate	ϕ_U	0.4
Pension replacement rate	ϕ_R	0.4
Output elasticity of capital	α	0.33
Depreciation rate	δ	$1.05^{1/12} - 1$
(b) Calibrated parameters		
Intertemporal elasticity of substitution	σ_C	0.8685
Output elasticity of on-the-job mortality		
– Through prevention costs	σ_y	0.0145
– Through absences	λ	612.84
Labor productivity (scale)	$\overline{y}$	693.77
Age profile of labor productivity	f_0, f_1, f_2	0.2163, 3.142×10^{-2}, -2.916×10^{-4}

calibrated model. Section 4.2.4 explores how the age-profile of on-the-job mortality responds to pension reforms and population aging. The descriptive statistics of the benchmark simulation and the counterfactual experiments can be found in Table A3 in the Supplementary material. Section 4.2.5 extends the analysis to a population with two skill groups.

4.2.1 Age profiles

Figure 4 shows the simulated age profiles of three key variables: wages, wealth, and on-the-job mortality. Panel A shows the age profile of the monthly wage, w_t. The curve is hump-shaped and due to our calibration strategy closely follows the red points that mark the data. Panel B shows that workers accumulate wealth a_t in order to finance consumption after retirement (note the different scaling of the horizontal axis in panel B compared to panels A and C). At the individual level, the process of wealth accumulation is interrupted by spells of unemployment, during which the individual partly finances consumption out of savings. This explains the increasing heterogeneity in wealth until retirement evident from the widening of the gray area. Finally, panel C



(A) Wage (B) Wealth (C) On-the-job mortality

Fig. 4 Age profiles of the monthly wage (**A**), wealth (**B**), and the on-the-job mortality rate (**C**). Notes: Gray areas indicate the range of all simulated profiles. Red points indicate the data. Data source: CFOI, CPS, own simulations

shows the on-the-job mortality rate computed as $\mu_t = -12\log(1-m_t)$.[27] The model generates an increasing age profile that provides a very good fit to the red points that indicate the estimates from the final mortality regression in Section 2. Note that our calibration only targeted the average level of the on-the-job mortality rate, but did not restrict its age profile.

We conclude that our behavioral economic model is able to replicate the stylized fact uncovered in Fig. 1 surprisingly well. The theoretical mechanisms that affect the age profile of on-the-job mortality in our model have already been discussed at the end of Section 3.4. Since $\chi = 0$ in our calibration, only three of the four potential channels are at work in the quantitative model. To explore their importance for the age profile of on-the-job mortality, we state the following theoretical result. The proof can be found in Supplementary material A.3

Proposition 1 *There exists a strictly increasing map* $\phi : \mathbb{R}^+ \to (0, \tilde{m})$ *with* $\tilde{m} = \frac{\sigma_y}{\lambda}$ *such that*

$$m_t = \phi\left(\frac{f(t)}{\hat{\pi}_t \mathrm{VoL}_{t|\mathcal{L}}}\right). \tag{17}$$

Importantly, the postulated function ϕ is independent of age, such that an increase in the argument directly leads to an increase in the equilibrium on-the-job mortality. Consistent with our qualitative insights from Section 3.4, Eq. 17 reveals that the increasing baseline mortality governed by the Gompertz law increases on-the-job mortality by lowering $\hat{\pi}_t$. However, the calibrated parameters of the baseline survival process imply that $\hat{\pi}_t$ decreases only very slowly in age, such that $\hat{\pi}_t = 0.999$ even at the age of retirement. Therefore, this channel turns out to be quantitatively negligible.

Equation 17 also highlights once again that m_t negatively depends on the value of life $\mathrm{VoL}_{t|\mathcal{L}}$. As speculated in Section 3.4, the value of life decreases towards the end of working life (compare the last row of Table 2), thereby pushing m_t upwards. The increasing pace of the reduction in the value of life also causes the age profile in Fig. 4C to become convex at later ages. By contrast, the increase in on-the-job

[27] Note that m_t is the probability of dying on the job during month t, while the values reported in Fig. 1 and Section 2 correspond to annualized hazard rates μ_t. The values are linked through $m_t = 1 - e^{-\mu_t/12}$.

Table 2 Value of a statistical life overall and by age

	Dependent variable: log(monthly wage)			
	Age=All (1)	Age=40 (2)	Age=50 (3)	Age=60 (4)
On-the-job mortality (per 100k)	0.0423 (0.00004)	0.0512 (0.00002)	0.0441 (0.00002)	0.0382 (0.00002)
Mean monthly wage ($)	2,887	2,970	3,128	3,114
VSL (million $)	12.21	15.21	13.80	11.88
$\text{VoL}_{\mathcal{L}}$ (million $)	11.69	12.27	11.11	9.61

Note: Regressions on simulated data. Value of a statistical life (VSL) computed as VSL $= \hat{\beta} \times \bar{w} \times 100{,}000$, $\text{VoL}_{\mathcal{L}}$ as mean value of life (VoL) of all employed individuals

mortality at the beginning of working life is mainly driven by the wage channel, more specifically by the concave age productivity profile $f(t)$ in Eq. 17. Since $f(t)$ starts to decrease after age 50, however, this channel dampens the increase in on-the-job mortality in late working life.

Since all workers of a given age face the same age-specific productivity $f(t)$ and baseline mortality $\hat{\pi}_t$, Eq. 17 also reveals that the heterogeneity in risk-taking indicated by the gray areas in Fig. 4C stems exclusively from differences in the value of life. This, in turn, results from different wealth levels. Interestingly, the mortality gap widens only gradually over the life cycle although wealth inequality is already pronounced in the early career. This can be explained by the forward-looking nature of the risk-taking decision. As long as the individual is sufficiently young, an unfavorable labor market history and accordingly low wealth could be compensated by positive labor market shocks in the future. This becomes less likely as workers age, such that individuals who have not yet been able to accumulate sufficient savings for retirement gradually start to accept higher risks to boost their income.[28] The relationship between wealth, wages, and on-the-job mortality is further explored in Section 4.2.3.

4.2.2 Compensating wage differentials and the value of a statistical life (VSL)

The value of a statistical life (VSL) measures the willingness to pay for a reduction in fatality by one in 100,000 workers over a year (Kniesner and Viscusi 2019). It is commonly estimated from observed variations in wages and fatal injury rates. As evident from Fig. 4, our model endogenously generates a distribution of wages and mortality at any given age, such that we can estimate the overall and age-specific VSL from simulated data and compare them to their empirical counterparts. Following the literature, we estimate a hedonic wage regression of the form

$$\log(w_{it}) = \alpha_t + \beta(m_{it} \times 10^5) + \varepsilon_{it}, \tag{18}$$

[28] Our choice of $\beta = 1$ ensures that the decline in the value of life, $\text{VoL}_{t|\mathcal{L}}$, is not driven by the subjective discounting.

where w_{it} is the monthly wage of agent i at age t, $m_{it} \times 10^5$ is the monthly probability of dying on the job (measured in terms of per 100,000 individuals), α_t are age-fixed effects, and ε_{it} is an error term. The average VSL is then computed as VSL $= \hat{\beta} \times \bar{w} \times 10^5$ where $\bar{w}$ is the average monthly wage in the economy.[29] Analogously, age-specific VSL values, VSL_t, can be obtained by restricting the estimation sample to specific age groups and multiplying with the average wage of the respective age group (Aldy and Viscusi 2008).

Table 2 shows the estimation results for the total population of workers and at three selected ages. The positive marginal effect of mortality on wages reveals that our model generates compensating wage differentials along the lines of Rosen (1986). In equilibrium, workers who take more risk are compensated with a higher wage. The point estimate in column 1 implies that workers that accept one additional death per 100,000 workers receive a 0.0423% higher wage. Multiplying this with the average wage yields a value of a statistical life of around 12.21 million dollars, which is in the empirically plausible range given in Kniesner and Viscusi (2019). Furthermore, the age-specific estimations show that the wage-mortality gradient becomes flatter with age, resulting in declining VSL values, consistent with the findings of Aldy and Viscusi (2008).

Additional to the VSL, Table 2 also reports the average value of life, VoL, as defined in Section 3.1. Although the computation of the two measures follow different concepts, Supplementary material A.4 shows that given the structure of our model, they are essentially the same. The main difference is that the VSL is based on gross wages, while the VoL takes into account the tax on labor income.

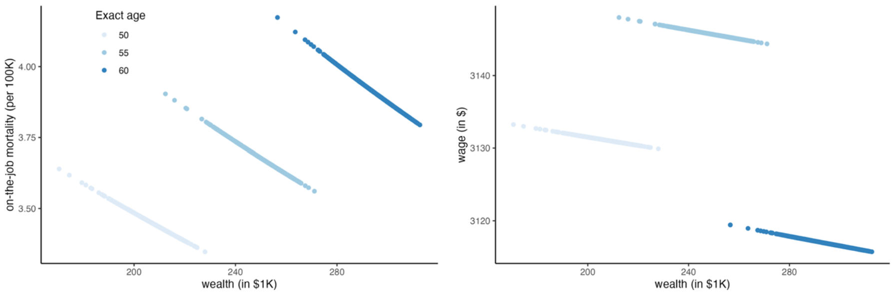
4.2.3 The effect of wealth on mortality and wages

As discovered in Fig. 4C, on-the-job mortality becomes increasingly dispersed towards the end of working life. Since our agents only differ by age and wealth, this indicates that wealth affects an individual's incentive to take risks on the job.

The effect of wealth on on-the-job mortality and wages is depicted in Fig. 5. Panel A plots wealth against on-the-job mortality at different ages. It is evident that at any given age, workers with higher wealth choose less mortality risk. At the same time, they earn lower wages (see panel B). This is because wealthier agents rely less on a high income to finance their consumption. They are therefore willing to give up part of their income to increase their survival probability. This rationale can be directly inferred from Fig. 3 since higher wealth increases the value of life. Furthermore, concavity of the net production function at the equilibrium implies that lower mortality is associated with a reduction in wages.

This observation implies that when all agents have the same underlying productivity ($\overline{y}_t$), at any given age, those who are wealthier accept a lower monthly wage income than those who are poorer, thereby reducing their risk to die on the job. Figure 5 also reveals that with increasing age, individuals are willing to trade-off wealth and mortality at an increasing rate as the line becomes steeper. The reason is that the

[29] The literature commonly uses the yearly fatality rate in Eq. 18 and multiplies the coefficient estimate with the average annual wage. We instead use the monthly probability and multiply with the average monthly wage. It is easy to see that both approaches to calculate the VSL are equivalent.



(A) On-the-job mortality (B) Wage

Fig. 5 Simulated age profiles of the relationship between wealth and on-the-job mortality (**A**) and the wage (**B**) at three exact ages

value of life in Eq. 17 becomes more sensitive to variations in wealth as the time until retirement shortens and less additional savings can be accumulated.

To quantify the effects observed in Fig. 5, we turn to a regression analysis and estimate the following two equations for employed individuals of age t on our simulated data,

$$\log(m_{it} \times 10^5) = \alpha_m + \beta_m \log(a_{it}) + u_{it}, \tag{19}$$

$$\log(w_{it}) = \alpha_w + \beta_w \log(a_{it}) + v_{it}, \tag{20}$$

where $m_{it} \times 10^5$ denotes the probability of dying on the job (measured in terms of per 100,000 individuals), a_{it} is the financial wealth, w_{it} is the wage level, while u_{it} and v_{it} are error terms. The estimated elasticities in Table 3 imply that a 50 year old with 10% higher wealth will choose a 2.96% lower on-the-job mortality rate at the expense

Table 3 Marginal effect of wealth on on-the-job mortality and wages

	Age=50 (1)	Age=55 (2)	Age=60 (3)
Dependent variable: log(on-the-job mortality)			
log(wealth)	−0.296	−0.384	−0.491
	(0.0004)	(0.0003)	(0.0003)
Constant	2.382	3.590	5.056
	(0.004)	(0.004)	(0.004)
Dependent variable: log(wage)			
log(wealth)	−0.004	−0.005	−0.006
	(0.00000)	(0.00000)	(0.00000)
Constant	8.094	8.113	8.121
	(0.0001)	(0.0001)	(0.0001)

Note: Regressions on simulated data

of a 0.04% lower wage. The elasticities are higher for a 60 year old with 4.91% and 0.06%, respectively.

4.2.4 The effect of pension reforms and aging

We can use our model to study how changes in the pension system and increases in life expectancy affect risk-taking on the job. To this purpose, we conduct three counterfactual experiments. In Experiment I, the retirement age is raised from 65 to 70. In Experiment II, the pension replacement rate is raised from $\phi_R = 0.4$ to 0.5. Experiment III considers a reduction in the baseline mortality by lowering the parameter α_π from $e^{-9.63}$ to $e^{-9.79}$, which increases life expectancy at birth by two years. Our main outcome of interest is the age-profile of on-the-job mortality, depicted in Fig. 6. Moreover, we present the age-specific welfare effects in terms of the consumption equivalent variation in Table 4. Additional descriptive statistics are reported in Table A3 in the Supplementary material.

In Experiment I, we observe that a higher retirement age leads to less risk-taking on the job, particularly in late working life. This is because later retirement increases future expected income and therefore the value of life at all ages. This effect is stronger at older ages than at younger ages due to a general equilibrium effect. As can be seen from Table A3, the longer working life increases aggregate labor supply and decreases the capital-labor ratio, which increases the equilibrium interest rate. As a consequence, consumption shifts from younger ages to older ages, which dampens the increase of the value of life at younger ages while amplifying it at older ages.

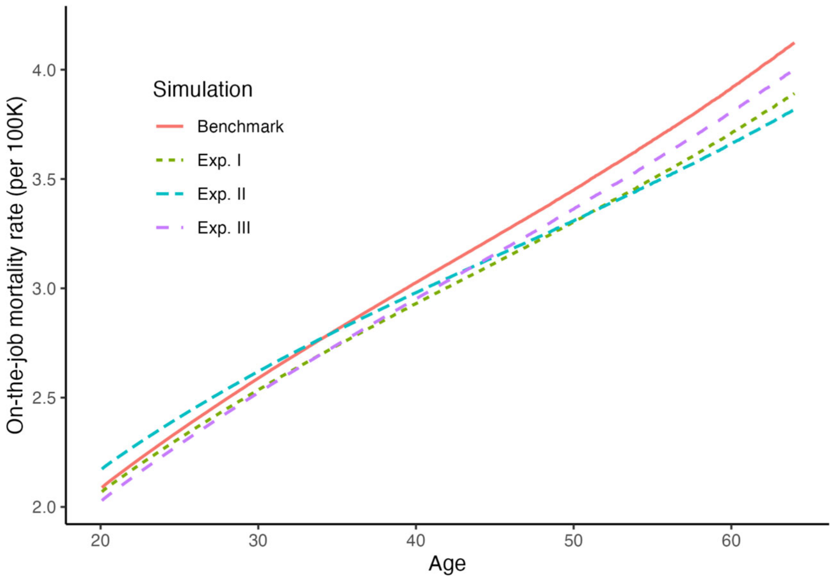


Fig. 6 Simulated age profiles of on-the-job mortality in four alternative simulations. Notes: Experiment I, higher retirement age; Experiment II, higher pension replacement rate; Experiment III, lower baseline mortality

Table 4 Welfare effects of pension reforms and aging by exact age

Age	Experiment I	Experiment II	Experiment III
20	7.68	−2.40	33.13
30	8.16	−0.96	37.74
40	8.61	0.48	43.25
50	8.98	1.93	49.65
60	9.19	3.39	56.71

Note: Welfare effects measured in consumption equivalent variation in percent relative to the benchmark case. Experiment I, higher retirement age; Experiment II, higher pension replacement rate; Experiment III, lower baseline mortality

The average wage decreases both due to the lower risk-taking on-the-job and the general equilibrium effect. Nevertheless, household labor income increases because the lower public spending on pensions reduces the equilibrium tax rate. This increases consumption and welfare across all ages (Table 4).[30]

In Experiment II, we observe that the effect of a higher pension replacement rate on on-the-job mortality depends on the worker's age. Workers below age 35 decide to take higher risk, while workers above age 50 reduce their risk even more than in Experiment I. Since higher pension benefits must be financed through a higher tax rate, the marginal benefit of risk-taking on the left-hand side of Eq. 7 decreases. It decreases more for older workers than for younger workers because their higher wage implies a larger monetary loss. The observation that younger workers actually increase risk-taking is due to a general equilibrium effect. The higher pension benefits reduce the need to save for retirement, such that aggregate wealth decreases. Similar to Experiment I, the capital-labor ratio decreases, which leads to a higher equilibrium interest rate. This increases the incentive to shift consumption into the future, which in turn reduces the value of life for young workers and increases the value of life for old workers. The general equilibrium effect dominates the partial equilibrium effect for young workers, while for old workers both effects act to reduce risk-taking on the job. The reaction of consumption and welfare also depends on age as evident from Table 4.

A reduction in the baseline mortality in Experiment III has a similar effect on the age profile of on-the-job mortality as delaying retirement in Experiment I. The lower baseline mortality reduces the marginal benefit of risk-taking on the left-hand side of Eq. 7 directly as well as indirectly through a higher value of life. In contrast to Experiment I, the tax rate increases as the share of retirees in the stationary population rises. This additionally reduces the incentive to take risk on the job, although the (gross) wage increases due to a general equilibrium effect. Compared to Experiments I, the reduction in on-the-job mortality is more balanced across the life-cycle. This is partly due to the lower interest rate, which increases the value of life at younger ages, while reducing it at older ages. While average consumption decreases due to a lower

[30] Importantly, we observe that whether a higher retirement age results in higher or lower on-the-job mortality depends on the response of wealth, which could go either way. Table A3 reports no substantial change in average wealth levels. If the effect on savings were sufficiently negative, however, individuals would find it optimal to take more risk when the retirement age is raised.

Table 5 Welfare effects of pension reforms and aging by skill group and exact age

Age	Experiment I		Experiment II		Experiment III	
	Low-skilled	High-skilled	Low-skilled	High-skilled	Low-skilled	High-skilled
20	5.63	11.51	−3.15	−0.42	31.68	36.19
30	5.97	11.99	−1.80	0.88	36.20	40.76
40	6.25	12.48	−0.46	2.17	41.66	46.20
50	6.42	13.00	0.89	3.48	48.03	52.50
60	6.32	13.57	2.26	4.82	55.12	59.42

Note: Welfare effects measured in consumption equivalent variation in percent relative to the benchmark case. Experiment I, higher retirement age; Experiment II, higher pension replacement rate; Experiment III, lower baseline mortality

net wage and the need to finance the additional years of life, the longer life expectancy substantially increases welfare at all ages (see Table 4).

It is evident from Table A3 that all our experiments result in a decrease in the average on-the-job mortality from 3.11 deaths to 3.00–3.03 deaths in 100,000 workers over a year. As discussed above, this effect is not homogeneous across the age distribution. A higher retirement age as well as a reduction in baseline mortality, which could be driven by medical advancements, reduces on-the-job mortality for all workers. The reduction is generally more pronounced at older ages because the incentive to take risk is more strongly affected. A higher pension replacement rate, on the other hand, does not benefit all workers. While the drop in on-the-job risk of older workers is more pronounced than in the other experiments, younger workers are inclined to take more risk due to an opposing wealth effect. They are also worse off in terms of welfare as evident from Table 4.

4.2.5 The effect of pension reforms and aging with two skill groups

In this section, we investigate the effect of pension reforms and aging on risk-taking on the job when the population consists of two skill groups (low-skilled and high-skilled). The model calibration involving two skill groups and the outcomes for the benchmark scenario are presented in Supplementary material A.7.[31] For comparison, we implement the same three counterfactual experiments as in the previous subsection. The resulting age profiles of on-the-job mortality by skill group are depicted in Fig. 7, and the corresponding welfare effects are given in Table 5.

Figure 7 is divided in three panels. The upper panel displays the age-profile of on-the-job mortality for the low-skilled group, while the middle panel presents the corresponding profiles for the high-skilled group in each experiment. Note that the on-the-job mortality rate for the low-skilled group is nearly ten times greater than that of the high-skilled group. To assess the differential impact of each experiment on

[31] Similar to Figs. 4, A4 in Supplementary material A.7 shows that our model is capable of generating age profiles of wages, wealth, and on-the-job mortality rates that fit well the data for two skill groups.

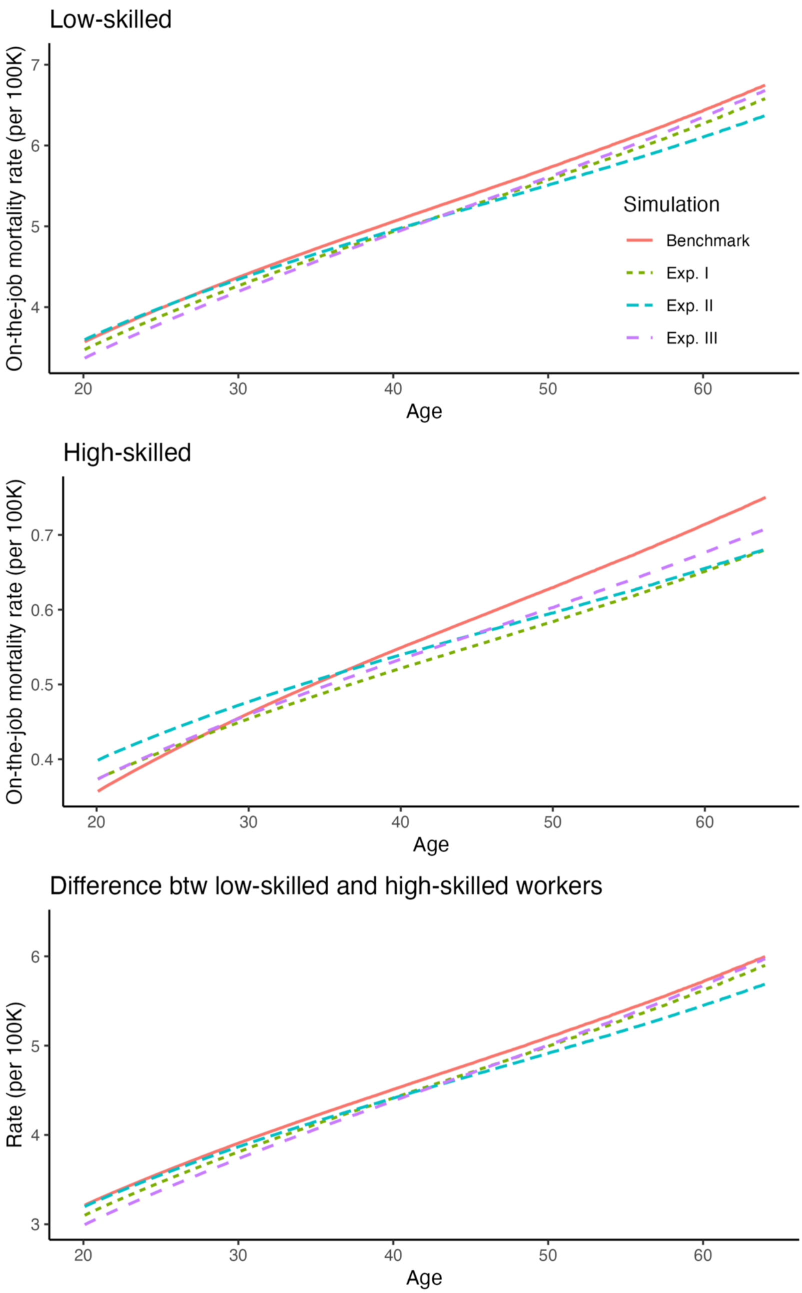


Fig. 7 Simulated age profiles of on-the-job mortality in four alternative simulations with two skill groups. Notes: Experiment I, higher retirement age; Experiment II, higher pension replacement rate; Experiment III, lower baseline mortality

both skill groups, the lower panel shows the mortality gap, i.e., the difference in the on-the-job mortality rate of low-skilled and high-skilled workers.

This panel reveals that all three experiments lead to a reduction in the mortality gap between the two groups when compared to the benchmark. This is because our calibration implies that reducing mortality is relatively more expensive for low-skilled workers than for high-skilled workers due to a higher output-elasticity of on-the-job mortality. In addition, low-skilled workers are more willing to give up wages with increasing wealth (see Table A6 in the Supplementary material). In Experiments I and II individuals do not need to accumulate as much wealth as in the benchmark, which facilitates giving up wage income to reduce risk-taking. Given that this effect is stronger for low-skilled workers than for high-skilled workers, the mortality gap across skill groups is reduced. By contrast, in Experiment III, the value of life of both skill groups increases relative to the benchmark (see Table A7 in the Supplementary material). Since low-skilled workers have a comparatively higher output elasticity of on-the-job mortality, an increase in the value of life leads to a stronger reduction of on-the-job mortality for low-skilled workers than for high-skilled workers.

Figure 7 also reveals that Experiments I and III exhibit more pronounced reductions in the mortality gap at younger ages than at older ages, whereas Experiment II showcases a stronger reduction in the mortality gap among older individuals compared to younger individuals. These age-specific variations in impact can be attributed to the same underlying factors as explained in Section 4.2.4.

Although the mortality gap between low-skilled and high-skilled workers decreases in all our experiments, Table 5 shows that high-skilled workers benefit more than low-skilled workers in terms of welfare. This is especially true for Experiment I, where a higher retirement age is assumed. This observation aligns well with recent findings, which show that when the normal retirement age is extended in a population characterized by a different life expectancy across skill groups, high-skilled workers tend to experience greater welfare gains than low-skilled workers (Sánchez-Romero et al. 2020, 2023).

5 Conclusion

Every year, more than 250,000 workers loose their lives due to work-related injuries or diseases in the US and the EU28 combined (Leigh 2011; European Agency for Safety and Health at Work 2017b). The incidence of occupational mortality is not equally distributed in the population. Not only mortality from work-related diseases increases in age, but also mortality from work-related injuries. This pattern remains even after controlling for occupation and a broad set of demographic characteristics. It runs counter the well-documented evidence that individuals reduce risks as they age (Dohmen et al. 2011; Rolison et al. 2014; Josef et al. 2016). To rationalize the age pattern of the occupational fatality rate from injuries, we present a life-cycle model where workers endogenously choose the mortality risk involved with their job. In equilibrium, workers face a trade-off between wages and on-the-job mortality. Our calibrated model is able to replicate the increasing pattern of occupational fatality risk in the US, suggesting that two mechanisms are at play. First, older workers' relatively higher wages make reductions in risk-taking more costly for them in monetary terms, increasing the marginal cost of risk reduction. Second, older workers have a lower value of life, such that the monetized utility that they lose in case of a deadly incident is lower compared to a younger worker. Therefore, the marginal benefit of risk reduction is decreasing in age. Both factors contribute to the increase in risk-taking observed in the data. Besides age, we find that individual wealth affects the optimal degree of risk-taking on the job. At any given age, wealthier individuals choose a lower on-the-job risk at the expense of lower wages. As a result, our model endogenously generates a mortality differential between individuals with a stable labor market history and workers who have been frequently unemployed. Finally, we explore three counterfactuals and their effect on the age pattern of on-the-job mortality. We observe that while an increase in pension benefits leads to the strongest reduction in on-the-job mortality of older workers in quantitative terms, it spurs higher risk-taking for younger workers. A higher retirement age as well as a reduction in baseline mortality, by contrast, benefits all workers. When the model is extended for two skill groups, all three counterfactuals act to reduce the mortality gap between low-skilled and high-skilled workers.

While our model is built on the premise of a frictionless labor market where on-the-job mortality is purely determined by the interplay of worker and firm incentives, additional channels may be at play in the real world. For instance, workers' influence over working conditions may be limited by search frictions. As search frictions increase in age, reducing mortality risk may become increasingly difficult for older workers due to a lack of alternative jobs. Kerndler (2023) analyzes a stationary model with search frictions and finds that the equilibrium level of on-the-job mortality indeed increases in the severity of the frictions. However, the frictions affect on-the-job risk only indirectly via the worker's value of life. This suggests that the decreasing value of life would still be the driving force behind the increasing age profile of on-the-job mortality even if our model were extended for search frictions. The increasing search frictions would mainly lead to a faster decline in the value of life without changing the basic mechanism.

An alternative explanation for the observed age pattern in fatal work-related injuries is increasing frailty or deteriorating health over the life-cycle. While we have shown that current health status does not significantly affect occupational fatality rates once other factors are controlled for (see Table A1 in the Supplementary material), negative health impacts may affect an individual's risk-taking incentive in a dynamic way. Since younger workers anticipate that health deficits incurred early on in life can have a long-lasting impact on health and labor market outcomes, worker's incentives to take risk may grow even stronger in age compared to our framework. In practice, this may be partly counteracted, however, by the fact that workers are more likely to be borrowing-constrained in their early careers, which gives them an additional incentive to increase their income by accepting more risky jobs. While also this channel is not explicitly modeled, our model endogenously gives rise to workers with lower wealth taking higher risks due their lower value of life.

In future research, it could be worthwhile to assess the quantitative contribution of some of these additional channels in shaping the age-profile of work-related mortality.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00148-025-01118-y.

Acknowledgements We thank Hippolyte d'Albis, David de la Croix, Michael Kuhn, Holger Strulik, Nawid Siassi, and the participants of the Max Planck/NBER workshop in June 2022 on Aging and Health, the ESPE conference in June 2023, and the NOeG conference in September 2023 for their helpful comments. We are also grateful for the suggestions of the editor, Gregory Ponthiere, and three anonymous referees.

Funding Open access funding provided by TU Wien (TUW). The authors acknowledge TU Wien Bibliothek for financial support through its Open Access Funding Programme. Miguel Sánchez-Romero acknowledges funding from the Austrian National Bank (OeNB) under Grant no. 18744.

Data availability All datasets used in the empirical analysis are publicly available from the cited official sources. The compiled dataset is available from the corresponding author upon reasonable request. Code to replicate the empirical and simulation results is available at https://doi.org/10.5281/zenodo.15838971.

Declarations

Conflict of interest The authors declare no competing interests.

References

Abeliansky AL, Strulik H (2023) Health and aging before and after retirement. J Popul Econ 36:1432–1475

Aldy JE, Viscusi WK (2008) Adjusting the value of a statistical life for age and cohort effects. Rev Econ Stat 90(3):573–581

Bellavance F, Dionne G, Lebeau M (2009) The value of a statistical life: a meta-analysis with a mixed effects regression model. J Health Econ 28(2):444–464

Bellés-Obrero C, Jiménez-Martín S, Ye H (2022) The effect of removing early retirement on mortality. IZA Discussion Paper (15577)

Boucekkine R, de la Croix D, Licandro O (2002) Vintage human capital, demographic trends, and endogenous growth. J Econ Theory 104(2):340–375

Bozio A, Garrouste C, Perdrix E (2021) Impact of later retirement on mortality: evidence from France. Health Econ 30(5):1178–1199

Cesarini D, Lindqvist E, Östling R, Wallace B (2016) Wealth, health, and child development: evidence from administrative data on Swedish lottery players. Quart J Econ 131(2):687–738

Dohmen T, Falk A, Huffman D, Sunde U, Schupp J, Wagner GG (2011) Individual risk attitudes: measurements, determinants and behavioral consequences. J Euro Econ Assoc 9(3):522–550

Eliason M, Storrie D (2009) Does job loss shorten life? J Human Resourc 44(2):277–302

Erixson O (2017) Health responses to a wealth shock: evidence from a Swedish tax reform. J Popul Econ 30(4):1281–1336

European Agency for Safety and Health at Work (2016) The ageing workforce: Implications for occupational safety and health — A research review

European Agency for Safety and Health at Work (2017a) An international comparison of the cost of work-related accidents and illnesses. https://osha.europa.eu/sites/default/files/2021-11/international_comparison-of_costs_work_related_accidents.pdf

European Agency for Safety and Health at Work (2017b) Data visualisation: The economics of occupational safety and health – the value of OSH to society. https://visualisation.osha.europa.eu/osh-costs#!/
European Commission (2021a) EU strategic framework on health and safety at work 2021–2027: Occupational safety and health in a changing world of work. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0323
European Commission (2021b) Green paper on ageing: fostering solidarity and responsibility between generations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:50:FIN
European Foundation for the Improvement of Living and Working Conditions (2008) Working conditions of an ageing workforce. Luxembourg: Office for Official Publications of the European Communities
Evans M, Schaur G (2010) A quantile estimation approach to identify income and age variation in the value of a statistical life. J Environ Econ Manag 59(3):260–270
Flood S, King M, Rodgers R, Ruggles S, Warren JR, Westberry M (2021) Integrated public use microdata series, current population survey: version 9.0 [dataset]
Galama TJ, Van Kippersluis H (2019) A theory of socio-economic disparities in health over the life cycle. Econ J 129(617):338–374
Gerdtham UG, Johannesson M (2003) A note on the effect of unemployment on mortality. J Health Econ 22(3):505–518
Hagen J (2018) The effects of increasing the normal retirement age on health care utilization and mortality. J Popul Econ 31(1):193–234
Hämäläinen P, Takala J, Saarela KL (2007) Global estimates of fatal work-related diseases. Am J Ind Med 50(1):28–41
Hämäläinen P, Saarela KL, Takala J (2011) Global estimates of fatal work-related diseases by region and disease group, 2002. Int J Occup Environ Health 17(1):49–56
Hammitt JK, Liu JT, Liu JL (2022) Is survival a luxury good? Income elasticity of the value per statistical life. J Risk Uncertain 65(3):239–260
Human Mortality Database (2023). https://www.mortality.org. (Data downloaded on January 17, 2023)
Ilmarinen J (2008) Towards a longer worklife! Ageing and the quality of worklife in the European Union, Finnish Institute of Occupational Health, Helsinki, Finland
Josef AK, Richter D, Samanez-Larkin GR, Wagner GG, Hertwig R, Mata R (2016) Stability and change in risk-taking propensity across the adult life span. J Person Soc Psychol 111(3):430–450
Kerndler M (2023) Occupational safety in a frictional labor market. Labour Econ 83(102388):1–20
Kniesner TJ, Viscusi WK (2019) The value of a statistical life. Oxford research encyclopedia of economics and finance
Lavetti K (2023) Compensating wage differentials in labor markets: empirical challenges and applications. J Econ Perspect 37(3):189–212
Lee R, Mason A (2011) Population aging and the generational economy: a global perspective. Edward Elgar, Cheltenham, UK
Lee R, Mason A, Miller T (2000) Life cycle saving and the demographic transition: the case of Taiwan. Popul Dev Rev 26:194–219
Leigh JP (2011) Economic burden of occupational injury and illness in the United States. Milbank Quart 89(4):728–772
Murphy KM, Topel RH (2006) The value of health and longevity. J Pol Econ 114(5):871–904
Paglione L, Angelici L, Davoli M, Agabiti N, Cesaroni G (2020) Mortality inequalities by occupational status and type of job in men and women: results from the Rome Longitudinal Study. BMJ Open 10(6):1–10
Pegula SM (2004) Occupational fatalities: self-employed workers and wage and salary workers. Monthly Labor Rev 127(3):30–40
Rolison JJ, Hanoch Y, Wood S, Liu PJ (2014) Risk-taking differences across the adult life span: a question of age and domain. J Gerontol Ser B 69(6):870–880
Rosen S (1986) The theory of equalizing differences. In: Ashenfelter OC, Layard R (Eds) Handbook of labor economics. Elsevier, vol 1, pp 641-692
Sánchez-Romero M, Sambt J, Prskawetz A (2013) Quantifying the role of alternative pension reforms on the Austrian economy. Labour Econ 22:94–114
Sánchez-Romero M, Lee RD, Prskawetz A (2020) Redistributive effects of different pension systems when longevity varies by socioeconomic status. J Econ Ageing 17(100259):1–13
Sánchez-Romero M, Schuster P, Prskawetz A (2023) Redistributive effects of pension reforms: who are the winners and losers? J Pension Econ Finance 1-27

Shimer R (2005) The cyclical behavior of equilibrium and vacancies unemployment. Am Econ Rev 95(1):25–49

Strulik H (2022) A health economic theory of occupational choice, aging, and longevity. J Health Econ 82(102599):1–20

Sullivan D, von Wachter T (2009) Job displacement and mortality: an analysis using administrative data. Quart J Econ 124(3):1265–1306

Thaler RH, Rosen S (1976) The value of saving a life: evidence from the labor market. In: Terleckyj NE (Ed) Household production and consumption. NBER, pp 265–302

Tompa E, Mofidi A, van den Heuvel S, van Bree T, Michaelsen F, van Jung Y, Emmerik M (2021) Economic burden of work injuries and diseases: a framework and application in five European Union countries. BMC Public Health 21(49):1–10

World Health Organization, International Labor Organization (2021) WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury, 2000–2016

Zulkarnain A, Rutledge MS (2018) How does delayed retirement affect mortality and health? (CRR Working Paper 2018-11)