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INTEGRATING CHRONIC HEALTH RISK FACTORS INTO PENSION LIABILITY AND MORTALITY ANALYSIS

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Abstract

This study examines how chronic health conditions influence pension liabilities by modeling long-term mortality risks associated with diseases such as cardiovascular disease, diabetes, and respiratory illnesses. Using a hypothetical dataset based on actuarial principles and mortality tables, it simulates the impact of these conditions on mortality rates and pension obligations under different interest rate scenarios (5%, 4.5%, 4%, and 3.5%). Results indicate that individuals with chronic illnesses face higher premiums, especially with cardiovascular disease, yet often result in lower pension liabilities due to reduced life expectancy. Respiratory diseases show a more balanced effect. The findings highlight a key trade-off: while chronic conditions increase short-term costs, they decrease long-term liabilities. The study underscores the importance of incorporating health data into actuarial models to improve mortality projections and financial planning for pension schemes, preventing underestimation of future liabilities. Recommendations include integrating health information, updating mortality assumptions regularly, and adopting policies to address the rising burden of chronic diseases in aging populations.

Keywords: Pension liabilities, Chronic health conditions, Mortality risk, Financial planning

1. INTRODUCTION

The global demographic landscape is undergoing a profound transformation characterised by increasing life expectancy and a rapidly growing aging population. According to the United Nations Department of Economic and Social Affairs (2019), the proportion of people aged 60 years and older is projected to nearly double from around 1 billion in 2020 to approximately 2.1 billion by 2050. Even more remarkable is the anticipated growth in those over 80 years old, a segment expected to expand at a faster rate due to medical and technological advancements. This demographic shift is primarily driven by improvements in healthcare, nutrition, sanitation, and preventive medicine, especially in high-income nations, which have contributed to longer lifespans, and healthier aging (United Nations Department of Economic and Social Affairs, 2019).

While these achievements are laudable, they also present substantial challenges to existing pension systems worldwide. As populations age, the traditional ratio of active workers to retirees shifts unfavorably, placing increased financial demands on pension funds. These schemes, whether public or private, often rely on assumptions of stable mortality rates and a predictable workforce, but demographic realities are now diverging sharply from these assumptions. Scholars like Piggott and Wood (2021) have emphasised that as the number of retirees grows relative to the working population, pension funds face heightened risks of underfunding and insolvency, necessitating reforms in pension policy, actuarial assumptions, and benefit structures to ensure sustainability.

The increase in life expectancy has also led to a rise in the prevalence of chronic health conditions

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among older adults. Diseases such as cardiovascular ailments, diabetes, respiratory illnesses, and various cancers now account for a significant proportion of mortality and morbidity worldwide. According to the World Health Organisation (2021), approximately 71% of all deaths globally are attributed to chronic diseases, which tend to develop over extended periods and often coexist with other health issues. The management of these chronic conditions often requires ongoing healthcare interventions, medications, and lifestyle adjustments that impose financial burdens on individuals, healthcare systems, and social insurance schemes alike.

This convergence of demographic aging and rising chronic morbidity complicates the task of accurately projecting pension liabilities. As a result, these models tend to underestimate mortality rates among populations with high prevalence of chronic conditions, leading to potential underestimation of pension liabilities and risk of underfunding. Research by Smith, Johnson, and Richards (2020) indicates that ignoring health factors can result in underestimations of pension liabilities by as much as 20%, which can have serious implications for the financial health of pension schemes.

Given this context, there is a pressing need to develop mortality risk models that incorporate health status, especially chronic conditions, to yield more accurate estimates of longevity and pension obligations. Such models would enable pension funds and policymakers to better anticipate future liabilities, allocate reserves appropriately, and design sustainable pension schemes resilient to demographic and health-related uncertainties. This study aims to address this crucial gap by examining the influence of chronic health conditions on mortality risk and pension liabilities, thereby providing a more insightful understanding of longevity and its financial implications.

The objectives of this research are multifaceted: firstly, to assess how chronic health conditions influence mortality risk and, consequently, pension liabilities; secondly, to evaluate how these conditions impact life expectancy; and thirdly, to analyse the broader financial implications for pension schemes. Achieving these aims will contribute valuable insights into the interplay between health and longevity, informing both actuarial practice and public policy. The significance of this work lies in its potential to improve the accuracy of pension liability projections, support sustainable pension system design, and promote public health strategies aimed at reducing the burden of chronic diseases among aging populations.

In sum, the demographic shift towards an older population, coupled with the rising prevalence of chronic health conditions, presents complex challenges for pension sustainability and economic stability. Addressing these issues requires innovative modeling approaches that reflect current health realities, enabling more effective financial planning and policy interventions to ensure the long-term viability of pension systems worldwide.

2.LITERATURE REVIEW

Research on chronic health conditions and mortality risk is crucial for understanding the link between public health and economic stability. Chronic diseases, with their long, often progressive courses, are central to global health issues. They influence mortality trends and place significant demands on healthcare, social services, and economies.

Epidemiological data identify cardiovascular disease, diabetes, respiratory illnesses, and cancers as leading causes of death worldwide. These illnesses develop gradually, influenced by lifestyle factors such as diet, activity, tobacco, alcohol, and environment. Many countries have shifted from high infectious disease burdens to rising non-communicable, chronic conditions, especially among aging populations (Agarwal, Ewald, & Wang, 2019). This trend necessitates a reassessment of health systems and social support, particularly for older adults. In Nigeria, Mojekwu and Adeyele (2010) examined mortality patterns among retired civil servants, showing that demographic factors like age, gender, income, and retirement choices significantly affect mortality trajectories. Adeyele (2011) further studied relationships between mortality patterns and at-risk populations, focusing on crude death rates and implications for retirement income.

Economically, chronic illnesses impose enormous costs. The CDC (2020) estimates that in the US, such diseases account for about 90% of healthcare spending, exceeding $4 trillion annually, covering

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hospital stays, outpatient care, medications, and long-term treatment. Beyond direct costs, productivity losses due to disability, absenteeism, and early retirement are significant. In Nigeria, where healthcare infrastructure is limited, these costs hit harder, with workers leaving the workforce prematurely or working less, worsening poverty and inequality (Omorodion, 2015).

Pension systems are deeply impacted. Traditional actuarial models rely on historical mortality data, assuming population homogeneity, and often neglect health status and disease prevalence. This can lead to underestimating future mortality in populations with high chronic disease rates, risking pension underfunding. Adeyele (2020) proposes an integral-transform-based actuarial model that better balances contributions and benefits, accounting for changing mortality assumptions. Curtis (2017) notes that rising life expectancy means individuals spend more years managing chronic conditions, supporting the "expansion of morbidity" hypothesis that longer lifespans may bring extended disability and health costs, straining healthcare and social insurance systems. Adeyele (2018) emphasizes that in valuing retirees' gratuities, mortality assumptions may underestimate liabilities because these payments aren't contingent on survival, highlighting the need for tailored assumptions.

Empirical evidence shows individuals with chronic diseases have shorter life expectancies. Haverkamp (2023) reports that respiratory and cardiovascular patients lose 5 to 10 years of life expectancy on average. These individuals often experience prolonged ill health, leading to earlier retirement, greater reliance on social support, and longer pension payouts. This underscores the importance of incorporating health status into mortality projections. Uncertainty in life expectancy heavily influences pension liabilities, making health risk factors vital for accurate modeling. In Nigeria, the absence of standardized annuity tables means reliance on general mortality data that overlook chronic disease risks, causing adverse selection—healthier individuals with longer life expectancies buy annuities, while those with chronic illnesses prefer lump sums. This distorts pension liabilities and threatens insurer stability, emphasizing the need for health-adjusted mortality models. Current models using average mortality rates tend to overestimate risks for healthy retirees and underestimate those for unhealthy ones.

Actuarial science is increasingly adopting health-adjusted models. Multistate models simulate transitions among health states—healthy, ill, disabled, deceased—offering dynamic longevity insights. Frailty models account for unobserved vulnerability due to genetic, environmental, or lifestyle factors. These methods aim to better predict mortality by capturing population heterogeneity. Since chronic diseases like cardiovascular issues, diabetes, and cancer greatly affect lifespan, their integration into pension and mortality models is critical. Conventional approaches relying on average rates risk misestimating liabilities—either underfunding or overfunding pensions. Incorporating health-adjusted assumptions aligns projections with demographic realities and enables fairer annuity pricing (Adeyele & Maituare; Adeyele, Maiturare & Ogungbenle, 2024).. Ultimately, considering chronic health risks enhances pension resilience and accuracy. However, practical challenges remain. Data limitations, especially in developing countries, hinder precise health transition estimates. Privacy concerns and model complexity also restrict widespread application. Most existing models are population-based and lack the granularity needed for individual liability assessments. There is an urgent need to develop models that include detailed health data—diagnoses, severity, progression—to improve longevity estimates and financial planning.

Hence, the literature underscores the significant impact of chronic health conditions on mortality risk and pension liabilities. Advances such as equilibrium modeling (Adeyele, 2020) and tailored assumptions (Adeyele, 2018) are promising, but challenges like data scarcity, complexity, and implementation barriers persist. Addressing these issues requires collaboration among researchers, policymakers, and pension practitioners to develop robust, health-sensitive mortality models that accurately reflect aging populations burdened by chronic disease.

3. METHODOLOGY

The data utilised in this study are grounded in established actuarial principles, including mortality tables and demographic trends. The dataset comprises information on hypothetical individuals with various chronic health conditions such as cardiovascular disease, diabetes, and respiratory illnesses.

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This simulated sample enables a comparative analysis of how these conditions influence mortality rates and, consequently, pension liabilities. The dataset includes variables like age, gender, specific health conditions, and other relevant demographic factors. Mortality rates are derived from assumed hazard functions, which are adjusted to reflect the presence of chronic conditions.

Pension liabilities are estimated by projecting future benefit payments based on the adjusted mortality rates for individuals with chronic health issues. The calculation involves determining the life expectancy for each subgroup from these mortality rates, which then informs the estimation of the financial obligations of pension schemes. Specifically, the present value of pension liabilities is calculated using a discount rate that accounts for the time value of money, ensuring the future payouts are expressed in current terms.

The core of the liability estimation hinges on the likelihood of survival to various ages and the corresponding payout projections over an individual's lifetime. To incorporate mortality risk, the survival curves are adjusted using hazard functions that reflect the influence of chronic conditions. The comparative analysis between individuals with and without these health issues allows for an assessment of the additional financial burden imposed by such conditions on pension funds.

For the model specification, the premium calculation is based on the mortality rate associated with each individual. Assuming that the premium is proportional to the expected present value of future benefits, the formula employed is:

$$P = L/\sum_{k=60}^{85} v(t).m(t) \qquad (1)$$

Where:

- L is the sum assured.
- v(t) is the discount factor, which adjusts for the interest rate at age t.
  $v(t) = (1 + r)^{-t}$
- m(t)is the adjusted mortality rate for the individual at age t.

This equation calculates the premium P required to cover the future liabilities based on the mortality rates.

This formula yields the premium PPP needed to cover expected future liabilities, incorporating mortality risk adjustments.

Regarding pension liability calculations, the present value of future pension payments at each age t is computed as:

The pension liability at each age is the present value of future pension payments, considering both the mortality rate and the interest rate. The liability at age t is:

$$L(t) = \sum_{k=60}^{85} v(k).m(k)\ .L \qquad (2)$$

Wnere:

- L(t) is the pension liability at age t
- v(k)is the discount factor for each future year k,
- m(k) is the adjusted mortality rate for each year.

The total pension liability for an individual is the sum of the liabilities at each age from 60 to 90, adjusted for mortality and discount factors.

4. RESULTS

The study explores mortality patterns and pension liability trends across various age groups and specific diseases including cardiovascular disease, diabetes, and respiratory illnesses under different interest rate scenarios. The analysis encompasses mortality rates, premium estimations, and pension liabilities, all of which are crucial for assessing the long-term viability of pension systems. Various interest rate assumptions are applied across all conditions, with adjustments made to mortality rates tailored to each disease.

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Table 1. Comparison of differences in premium and pension liabilities between All lives and individual diseases at 5% interest rates

Age	Interest Rate	Cardio Premium Difference (%)	Diabetes Premium Difference (%)	Respiratory disease difference (%)	Cardio Pension Liability Difference (%)	Diabetes Pension Liability Difference (%)	Respiratory Pension Liability difference (%)
60	0.0500	42.89%	36.08%	31.06%	-8.00%	0.00%	0.00%
61	0.0500	41.67%	36.29%	31.73%	-6.13%	-0.97%	-0.847%
62	0.0500	40.51%	36.73%	32.16%	-6.51%	-1.94%	-0.94%
63	0.0500	39.65%	36.80%	33.70%	-7.00%	-2.41%	-1.41%
64	0.0500	39.00%	37.19%	34.45%	-7.31%	-2.87%	-1.87%
65	0.0500	38.19%	37.34%	34.99%	-7.97%	-4.33%	-2.33%
66	0.0500	37.56%	37.83%	35.49%	-8.97%	-5.79%	-2.79%
67	0.0500	36.73%	38.88%	35.67%	-10.38%	-6.24%	-3.24%
68	0.0500	35.78%	39.25%	36.47%	-12.12%	-6.71%	-3.71%
69	0.0500	34.85%	39.82%	37.01%	-13.95%	-7.17%	-4.17%
70	0.0500	34.11%	40.45%	38.93%	-16.21%	-7.62%	-4.62%
71	0.0500	33.03%	40.65%	39.48%	-19.05%	-8.05%	-5.05%
72	0.0500	32.27%	41.21%	40.04%	-21.97%	-8.53%	-5.53%
73	0.0500	31.62%	41.72%	41.43%	-25.11%	-8.98%	-5.98%
74	0.0500	30.74%	42.56%	42.16%	-28.57%	-9.41%	-6.41%
75	0.0500	30.03%	43.47%	43.39%	-32.21%	-9.83%	-6.83%
76	0.0500	28.77%	44.02%	44.04%	-36.08%	-9.93%	-7.30%
77	0.0500	27.83%	44.47%	44.47%	-40.43%	-10.01%	-7.70%
78	0.0500	26.76%	45.05%	45.01%	-44.49%	-10.18%	-8.18%
79	0.0500	25.73%	45.77%	45.73%	-49.04%	-10.60%	-8.60%
80	0.0500	25.00%	46.62%	46.08%	-54.43%	-11.01%	-9.01%
81	0.0500	23.91%	47.06%	47.05%	-59.39%	-11.46%	-9.46%
82	0.0500	22.94%	47.74%	47.27%	-64.74%	-11.86%	-9.86%
83	0.0500	22.13%	48.40%	48.13%	-70.26%	-12.31%	-10.31%
84	0.0500	21.16%	48.54%	48.20%	-75.96%	-13.72%	-10.72%
85	0.0500	20.31%	49.25%	49.08%	-81.65%	-14.14%	-11.14%

Source: Authors' computation

Premium disparities for cardiovascular disease, diabetes, and respiratory illnesses diminish as age increases, with diabetes consistently exhibiting the highest percentage differences and respiratory diseases the lowest. Pension liability differences are negative across all conditions, intensifying with age—particularly for cardiovascular disease. The reduction in premium differences occurs more gradually for respiratory diseases, whereas pension liabilities display a steeper, nonlinear decline, especially after age 70. Overall, adjustments for diabetes exert the greatest effect on premiums, while cardiovascular disease has the most significant impact on pension liabilities.

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Table 2 Comparison of differences in premium and pension liabilities between all lives and individual diseases at 4.5% interest rates

Age	Interest Rate	Cardio Premium Difference (%)	Diabetes Premium Difference (%)	Respiratory disease difference (%)	Cardio Pension Liability Difference (%)	Diabetes Pension Liability Difference (%)	Respiratory Pension Liability difference (%)
60	0.0450	38.34%	33.33%	23.06%	-3.00%	0.00%	0.00%
61	0.0450	36.96%	34.07%	28.73%	-3.13%	-0.47%	-0.27%
62	0.0450	35.38%	34.18%	30.16%	-4.51%	-0.94%	-0.44%
63	0.0450	34.04%	35.06%	31.70%	-5.00%	-1.41%	-1.11%
64	0.0450	33.04%	35.94%	33.45%	-6.31%	-1.87%	-1.27%
65	0.0450	31.39%	36.39%	34.99%	-7.97%	-2.33%	-2.73%
66	0.0450	30.39%	37.14%	35.49%	-8.97%	-2.79%	-2.79%
67	0.0450	29.44%	38.04%	37.67%	-10.38%	-3.24%	-3.24%
68	0.0450	28.66%	38.56%	38.47%	-12.12%	-3.71%	-3.71%
69	0.0450	27.97%	39.14%	39.01%	-13.95%	-4.17%	-4.17%
70	0.0450	27.47%	40.03%	39.93%	-16.21%	-4.62%	-4.62%
71	0.0450	27.24%	40.47%	40.48%	-19.05%	-5.05%	-5.05%
72	0.0450	26.67%	41.21%	41.04%	-21.97%	-5.53%	-5.53%
73	0.0450	26.32%	41.92%	41.43%	-25.11%	-5.98%	-5.98%
74	0.0450	25.97%	42.56%	42.16%	-28.57%	-6.41%	-6.41%
75	0.0450	25.78%	43.22%	43.39%	-32.21%	-6.83%	-6.83%
76	0.0450	25.30%	44.02%	44.67%	-36.08%	-7.30%	-7.30%
77	0.0450	24.75%	44.74%	45.47%	-40.43%	-7.70%	-8.70%
78	0.0450	24.05%	45.35%	46.01%	-44.49%	-8.18%	-9.18%
79	0.0450	23.17%	46.03%	46.73%	-50.04%	-8.60%	-10.60%
80	0.0450	22.34%	46.79%	47.08%	-59.43%	-9.01%	-11.01%
81	0.0450	21.53%	47.43%	48.05%	-62.39%	-9.46%	-12.46%
82	0.0450	20.93%	48.05%	49.56%	-63.74%	-9.86%	-12.86%
83	0.0450	20.39%	48.91%	49.31%	-64.26%	-10.31%	-13.31%
84	0.0450	19.71%	49.51%	50.34%	-65.96%	-10.72%	-13.72%
85	0.0450	19.03%	50.26%	52.96%	-71.65%	-11.14%	-14.14%

Source: Authors' computation

At an interest rate of 4.5%, premium differences across all disease categories diminish with age, with diabetes displaying the largest disparities, followed by respiratory diseases and cardiovascular diseases. Pension liability differences also decrease significantly as age advances, with cardiovascular diseases exhibiting the steepest decline. Diabetes shows a more gradual reduction in pension liabilities, while respiratory diseases follow a steady downward trend similar to cardiovascular diseases. Overall, both premiums and pension liabilities tend to decrease with age, though the pace of decline varies among different disease categories.

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Table 3 Comparison of differences in premium and pension liabilities between All lives and individual diseases at 4% interest rates

Age	Interest Rate	Cardio Premium Difference (%)	Diabetes Premium Difference (%)	Respiratory disease premium differences (%)	Cardio Pension Liability Difference (%)	Diabetes Pension Liability Difference (%)	Respiratory Pension Liability difference (%)
60	0.0400	43.38%	33.33%	31.06%	-2.32%	0.00%	0.00%
61	0.0400	41.71%	34.07%	31.73%	-3.13%	-0.47%	-0.17%
62	0.0400	40.37%	34.18%	32.16%	-5.51%	-0.94%	-0.34%
63	0.0400	39.10%	35.06%	33.70%	-6.00%	-1.41%	-1.01%
64	0.0400	37.95%	35.94%	34.45%	-7.31%	-1.87%	-1.97%
65	0.0400	36.63%	36.39%	35.99%	-7.97%	-2.33%	-2.33%
66	0.0400	35.72%	37.14%	36.49%	-8.97%	-2.79%	-3.79%
67	0.0400	34.65%	38.04%	37.67%	-10.38%	-3.24%	-4.24%
68	0.0400	33.77%	38.56%	38.47%	-12.12%	-3.71%	-4.71%
69	0.0400	32.83%	39.14%	39.01%	-13.95%	-4.17%	-5.17%
70	0.0400	31.67%	40.03%	39.93%	-16.21%	-4.62%	-5.62%
71	0.0400	30.00%	40.47%	40.48%	-19.05%	-5.05%	-6.05%
72	0.0400	28.47%	41.21%	41.04%	-21.97%	-5.53%	-6.13%
73	0.0400	27.22%	41.92%	41.43%	-25.11%	-5.98%	-6.38%
74	0.0400	26.04%	42.56%	42.16%	-28.57%	-6.41%	-6.41%
75	0.0400	24.84%	43.22%	42.39%	-32.21%	-6.83%	-6.83%
76	0.0400	23.37%	44.02%	43.04%	-36.08%	-7.30%	-7.30%
77	0.0400	21.93%	44.74%	43.47%	-40.43%	-7.70%	-7.70%
78	0.0400	20.28%	45.35%	44.01%	-45.49%	-8.18%	-8.18%
79	0.0400	18.70%	46.03%	44.73%	-46.04%	-8.60%	-8.60%
80	0.0400	17.16%	46.79%	45.08%	-47.43%	-9.01%	-8.91%
81	0.0400	15.47%	47.43%	45.05%	-48.39%	-9.46%	-8.96%
82	0.0400	13.99%	48.05%	46.27%	-49.74%	-9.86%	-9.66%
83	0.0400	12.56%	48.91%	46.13%	-50.26%	-10.31%	-10.41%
84	0.0400	11.02%	49.51%	47.20%	-55.96%	-10.72%	-11.72%
85	0.0400	9.65%	50.26%	47.08%	-61.65%	-11.14%	-12.64%

Source: Authors' computation.

Table 3 illustrates that, at age 60, premiums for individuals with specific diseases such as cardiovascular issues, diabetes, and respiratory conditions are significantly higher compared to the general "All Lives" category, with differences ranging from approximately 31% to 43%. However, as age increases, these premium differences gradually decrease, indicating that the premium gap narrows over time. By age 85, the premium differences for cardiovascular conditions decrease to around 9.65%, while for diabetes and respiratory diseases, the differences actually increase, reaching over 50%. This suggests that the relative cost of insuring individuals with these diseases becomes more pronounced at older ages, particularly for diabetes and respiratory conditions.

In contrast, pension liabilities for individuals with these diseases tend to be lower than those for the overall population, with the differences becoming more negative as age advances. Starting from near zero or slightly negative at age 60, the liability differences deepen significantly by age 85. For example, the pension liabilities for cardiovascular disease are estimated to be about 61.65% lower compared to "All Lives," while for diabetes and respiratory diseases, the reductions are approximately 11% to 13%. This trend indicates that the projected pension liabilities for individuals with these health conditions decrease with age, likely reflecting shorter expected lifespans or higher mortality associated with these diseases in older populations.

In general, the data suggests that while premiums for individuals with specific diseases are initially higher, the difference diminishes or even reverses at advanced ages, especially for cardiovascular conditions. Meanwhile, pension liabilities for these groups tend to be lower than the general population and become significantly reduced as age increases. These patterns underscore the differing risk profiles and actuarial considerations involved in pricing and liability estimation for populations with specific health conditions compared to the broader population.

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Table 4 Comparison of differences in premium and pension liabilities between all lives and individual diseases at 3.5% interest rates

Age	Interest Rate	Cardio Premium Difference (%)	Diabetes Premium Difference (%)	Respiratory disease difference (%)	Cardio Pension Liability Difference (%)	Diabetes Pension Liability Difference (%)	Respiratory Pension Liability difference (%)
60	0.0350	38.34%	33.33%	33.06%	-3.22%	0.00%	0.00%
61	0.0350	36.96%	34.07%	33.73%	-4.13%	-0.47%	-0.87%
62	0.0350	34.16%	34.18%	34.16%	-5.51%	-0.94%	-0.98%
63	0.0350	34.04%	35.06%	34.70%	-6.00%	-1.41%	-1.41%
64	0.0350	33.04%	35.94%	35.45%	-6.31%	-1.87%	-1.67%
65	0.0350	35.99%	36.39%	35.99%	-7.97%	-2.33%	-2.33%
66	0.0350	36.49%	37.14%	36.49%	-8.97%	-2.79%	-2.79%
67	0.0350	37.67%	38.04%	37.67%	-10.38%	-3.24%	-3.64%
68	0.0350	38.47%	38.56%	38.47%	-12.12%	-3.71%	-3.71%
69	0.0350	39.01%	39.14%	39.01%	-13.95%	-4.17%	-4.27%
70	0.0350	39.93%	40.03%	39.93%	-16.21%	-4.62%	-4.62%
71	0.0350	40.48%	40.47%	40.48%	-19.05%	-5.05%	-5.15%
72	0.0350	41.04%	41.21%	41.04%	-21.97%	-5.53%	-5.53%
73	0.0350	41.43%	41.92%	41.43%	-25.11%	-5.98%	-5.98%
74	0.0350	42.16%	42.56%	42.16%	-28.57%	-6.41%	-6.41%
75	0.0350	43.39%	43.22%	43.39%	-32.21%	-6.83%	-6.83%
76	0.0350	44.04%	44.02%	44.04%	-36.08%	-7.30%	-7.30%
77	0.0350	44.47%	44.74%	44.47%	-40.43%	-7.70%	-7.70%
78	0.0350	45.01%	45.35%	45.01%	-44.49%	-8.18%	-8.18%
79	0.0350	45.73%	46.03%	46.73%	-49.04%	-8.60%	-8.60%
80	0.0350	46.08%	46.79%	47.08%	-54.43%	-9.01%	-9.01%
81	0.0350	47.05%	47.43%	48.05%	-69.39%	-9.46%	-9.46%
82	0.0350	47.27%	48.05%	48.27%	-74.74%	-9.86%	-9.86%
83	0.0350	48.13%	48.91%	49.13%	-77.26%	-10.31%	-11.31%
84	0.0350	48.20%	49.51%	49.20%	-78.96%	-10.72%	-12.72%
85	0.0350	49.08%	50.26%	49.88%	79.65%	-11.14%	-13.14%

Source: Authors' computation

When the interest rate drops to 3.5%, both premium differences and pension liabilities tend to increase across the three diseases: cardiovascular, diabetes, and respiratory. Premium differences for all conditions gradually rise with age, whereas pension liabilities experience a much sharper decline. For example, premiums for cardiovascular disease can increase by up to 49% for individuals aged 85, while pension liabilities decrease significantly, particularly for cardiovascular and respiratory diseases. At older ages, respiratory disease premiums and liabilities reach their highest levels, indicating that the financial impact becomes more substantial for individuals with respiratory conditions as the interest rate decreases.

DISCUSSION OF FINDINGS

This study offers a detailed comparison of premiums and pension liabilities linked to three common chronic diseases cardiovascular disease, diabetes, and respiratory illnesses and contrasts these with aggregate outcomes across the entire population at interest rates ranging from 3.5% to 5%. The findings highlight the intricate relationship between age, interest rates, health status, and their combined effects on pension scheme obligations.

Across the age range from 60 to 85, a clear pattern emerges: the differences in premiums between individuals with specific chronic conditions and the general population tend to diminish as age increases. This trend indicates that the relative financial risk imposed by these health conditions is more significant at younger ages within the retirement period but becomes less impactful as mortality risk naturally rises with age. Notably, diabetes and respiratory diseases tend to generate higher premium differentials than cardiovascular conditions at similar ages. This suggests that, in terms of immediate financial impact, these diseases pose a greater short-term risk, possibly because of their progression patterns and associated mortality rates.

Pension liabilities associated with these

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conditions also decline markedly with age. This decline is especially pronounced for cardiovascular diseases, where shorter expected remaining lifespans reduce long-term obligations. At higher interest rates such as 5%—the present value of future liabilities decreases more sharply, emphasising the sensitivity of pension obligations to both the discount rate and mortality assumptions. Cardiovascular conditions show the greatest sensitivity, with pension liabilities dropping significantly at elevated interest rates, underscoring the importance of accurate mortality modeling for financial planning.

This distinct analysis underscores the necessity of considering both age and interest rate variations when assessing the financial implications of chronic conditions. The differential impacts among the three diseases reveal that while individuals with these conditions face higher premiums reflecting increased mortality risk their long-term pension liabilities are comparatively lower, especially at older ages where survival prospects diminish. This trade-off highlights a critical balancing act: higher initial costs to cover increased mortality risk versus reduced future pension obligations, a challenge that pension fund managers must navigate carefully.

When comparing aggregate outcomes for the entire population against those with specific health conditions, several patterns are evident across interest rates of 5%, 4.5%, 4%, and 3.5%. For cardiovascular conditions, premiums consistently exceed those for the broader population, with the percentage difference widening with age. This indicates that cardiovascular health significantly elevates financial risk, requiring higher premiums to buffer against increased mortality.

Similarly, premiums for individuals with diabetes tend to be higher than for the overall population, though the margin is slightly narrower than for cardiovascular conditions. Respiratory diseases show a comparable pattern but generally have premiums somewhat lower than those for cardiovascular and diabetes at similar ages. Despite higher premiums for these health conditions, total pension liabilities representing the projected sum of future benefit payments are higher for the general population across all age groups. Interestingly, pension liabilities for individuals with cardiovascular disease and diabetes decline with age, reflecting their shorter remaining lifespans and the reduced duration of pension payouts.

In contrast, liabilities for individuals with respiratory diseases display a more balanced pattern, with less steep declines over age. While these individuals face higher immediate costs, their potentially longer survival may extend pension obligations, though the overall financial impact remains lower than that of the general population. As interest rates decrease, the premium gaps between healthy individuals and those with chronic conditions tend to narrow slightly, but the overall trend of higher premiums for health-compromised individuals persists. This consistency underscores the persistent risk premium associated with chronic illnesses, regardless of the discount rate environment.

A key insight from this analysis is that individuals with chronic health conditions generally bear a larger initial financial burden in premiums due to elevated mortality risks. However, this is offset over time by lower pension liabilities, as reduced life expectancy shortens the duration of pension payouts. This trade-off emphasises the importance of incorporating detailed health status data into actuarial models. Properly calibrated models can help pension schemes balance increased early costs against long-term liability reductions, supporting more sustainable financial management.

Overall, the findings demonstrate that the presence of chronic health conditions significantly influences both the premiums required and the projected pension liabilities. The different effects among cardiovascular disease, diabetes, and respiratory illnesses reveal the need for pension funds to develop health-sensitive models that accurately reflect mortality risks associated with each condition. Neglecting these factors could lead to underestimating liabilities and threaten pension sustainability.

5. CONCLUSION AND RECOMMENDATIONS

This study provides valuable empirical evidence on how chronic health conditions particularly respiratory diseases impact mortality risk and pension liabilities.

The core conclusion is that such conditions

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substantially increase mortality risk, leading to higher premiums and shorter life expectancies. Respiratory illnesses, in particular, have the most pronounced effect, reinforcing the importance of adjusting pension models to account for these health risks.

The reduction in life expectancy associated with these conditions directly affects pension liabilities. For individuals aged 60 to 85, the presence of chronic illnesses significantly shortens remaining lifespans, thereby decreasing the total future pension payouts. This effect is especially notable at lower interest rates, where pension liabilities are highly sensitive to mortality assumptions. Failing to incorporate the increased mortality risk posed by chronic conditions can result in substantial underestimation of obligations, risking the financial health of pension schemes.

The analysis confirms that integrating chronic health conditions into actuarial models enhances the accuracy of mortality projections. Traditional models that omit these health factors tend to underestimate mortality risk, potentially leading to underfunding and shortfalls. Including detailed health data enables pension administrators to better anticipate future liabilities, adjust premiums, and build reserves aligned with the true underlying risks.

The study underscores the necessity for pension systems to adapt to demographic shifts driven by aging populations and rising chronic disease prevalence. As the burden of these health issues grows, pension schemes must revise their assumptions to incorporate health-adjusted mortality rates and develop strategies such as differentiated premiums, targeted health promotion, and benefit adjustments aligned with life expectancy variations.

Regular reviews of mortality assumptions, incorporating current health and epidemiological data, are essential. Proactive adjustments to premiums and payouts will help ensure pension schemes remain resilient and capable of meeting their obligations amid evolving health and demographic trends.

Recommendations

Based on these findings, it is advisable for pension fund managers to systematically incorporate data on chronic health conditions such as cardiovascular disease, diabetes, and respiratory illnesses into their actuarial assessments. This will improve the accuracy of mortality risk estimates and lead to better premium setting and liability projections. Regular updates to mortality assumptions are vital, considering ongoing health trends and medical advancements that influence longevity.

Implementing differential premiums that reflect individual health profiles can promote fairness and sustainability. Beneficiaries with chronic conditions should face appropriately higher premiums to compensate for increased mortality risk, and payout structures could be adjusted to account for shorter expected lifespans. Such measures help balance contributions with actual risks.

Promoting health and wellness programs among pension beneficiaries can also serve as preventative strategies, potentially reducing the severity or delaying the progression of chronic diseases. Governments and pension providers are encouraged to invest in initiatives aimed at healthier lifestyles, early detection, and disease management. These efforts can extend beneficiaries' active years, decrease healthcare costs, and ultimately lower pension liabilities.

On a policy level, integrating healthcare, long-term care, and pension systems can offer comprehensive support for aging populations. This holistic approach addresses the complex challenges posed by chronic diseases, ensuring pension funds are better prepared to meet future liabilities while promoting healthier aging.

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