

ACTUARIAL ANALYSIS OF HISTORICAL MORTALITY TRENDS IN NIGERIA AND THEIR IMPLICATIONS FOR ANNUITY VALUATION

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ABSTRACT

This study analyses historical trends and patterns in age-specific mortality in Nigeria and their actuarial implications for annuity valuation. Using secondary data from the United Nations World Population Prospects (2024 revision), the study applied descriptive and trend analysis to age-specific death rates and life expectancy across selected ages from 1960 to 2024. Descriptive statistics, graphical trends, and comparative assessments were used to evaluate improvements in mortality by age and gender. The results show a consistent decline in mortality rates over time, with the fastest improvements observed among children and young adults, and slower reductions among older adults. Female mortality rates remained consistently lower than those of males, reflecting global longevity patterns. These findings indicate that longevity risk is increasing for pension and annuity providers as Nigerians live longer. The study concludes that periodic review of mortality assumptions is essential for accurate pricing and reserving. It recommends integrating actuarial analysis into national mortality monitoring to strengthen the financial sustainability of life-contingent products.

Keywords: Actuarial analysis, mortality, mortality trends, annuity valuation, pension, Nigeria

1. INTRODUCTION

Understanding mortality dynamics is fundamental to actuarial science, as mortality patterns and trends directly influence life insurance pricing, pension valuation, and annuity reserving. Globally, mortality rates have declined significantly over the past few decades, while life expectancy has risen due to improvements in nutrition, healthcare, living standards, and technological advancement (United Nations Population Division, 2022). Sudharsanan et al. (2022) observed that the pace and pattern of this decline vary considerably across countries. In Nigeria, the mortality rate has fallen from 13.24 to 10.83 deaths per 1,000 population over the past decade (United Nations, 2024). Boumezoued et al. (2021) suggest that such declines are driven by epidemiological and socioeconomic progress, which continue to redefine longevity risk and affect the financial sustainability of life-contingent businesses.

For actuaries, credible mortality data and consistent trend analysis are essential for forecasting future liabilities and managing longevity risk. Despite its centrality to actuarial valuation, mortality modeling has received limited attention in Nigeria's pension and insurance sectors. Most existing Nigerian studies focus on public health or demographic outcomes without linking mortality trends to financial implications for insurers and pension funds (Ukoji & Ukoji, 2023; Adebowale et al., 2022; Obiorah, 2020). By contrast, actuarial research in developed countries often applies deterministic and stochastic models such as the Lee-Carter or Cairns-Blake-Dowd models to project mortality and evaluate their impact on pension funding and annuity pricing (Cairns et al., 2006; Lee & Carter, 1992). These studies used age-specific mortality rates as key variables, analysing improvement trends and quantifying their effect on life-contingent valuations. Comparable actuarial-based analyses in Nigeria remain scarce, creating a gap in understanding how local mortality dynamics affect financial obligations in pension and life insurance portfolios.

Against this background, this paper examines historical mortality dynamics in Nigeria using United Nations mortality data from 1960 to 2024. The study investigates how mortality levels and improvement rates have evolved across ages and genders, and interprets these changes in the context of longevity risk and actuarial valuation. By exploring the extent to which declining mortality affects pension liabilities and annuity reserving, the study provides empirical insight into the actuarial implications of demographic transition in Nigeria. In doing so, it contributes to the growing literature that integrates demographic analysis with actuarial modeling in emerging economies.

2. REVIEW OF LITERATURE

Conceptual Review

Mortality

Mortality refers to the frequency of death in a population over time and underpins actuarial assessments of survival and longevity. While demographers view mortality as a measure of population health, actuaries interpret it as a stochastic process that influences the valuation of life-contingent liabilities such as pensions and annuities (Richards & Macdonald, 2024; Lee & Carter,

1992). In this study, mortality is conceptualised not only as a demographic indicator but also as a financial variable whose trends and patterns determine the sustainability of life insurance portfolios in Nigeria. This dual perspective provides the basis for linking mortality dynamics with actuarial valuation and longevity risk management. (Richards & Macdonald, 2024; Kshatriya & Kameih, 2017).

Age-Specific Death Rate and Probability of Death

The age-specific death rate (ASDR), denoted by mx , represents the ratio of deaths occurring at a particular age x to the population at that age. It reflects the intensity of mortality within specific age range and forms the empirical foundation for constructing life tables. Closely related to this is the probability of death, qx , which measures the likelihood that a person aged x will die before reaching age $x+1$ (the next birthday). These measures operationalize mortality and form the empirical basis for constructing life tables, projecting longevity, and valuing life-contingent liabilities in actuarial practice.

Mortality Improvement

Following the measurement of mortality through age-specific death rates, it is equally important to understand how these rates evolve over time. Mortality improvement refers to the systematic decline in death rates over time due to advancements in healthcare, standard of living, and technology. Actuaries measure this improvement to assess how survival probabilities evolve across years and to project the financial implications of higher life expectancies. Monitoring mortality improvement is essential for updating life tables, pricing life annuities, and setting assumptions for solvency and reserving. Persistent mortality improvements imply higher longevity risk for insurers and pension funds, as individuals live longer than originally expected (Carannante et al., 2024).

Longevity and Actuarial Implications

The persistent improvement in mortality naturally translates into increased longevity, the tendency for individuals to live longer as death rates decline (Institute and Faculty of Actuaries, 2017). While increased longevity is a social and public health achievement, it presents significant financial challenges for actuarial practitioners. Increase in life expectancy mean extended annuity payments, increased pension liabilities, and potential solvency pressures for insurers. From an actuarial standpoint, longevity risk arises when actual improvements in mortality exceed the assumptions used in pricing and reserving models (Gyamerah et al., 2024; Barrieu et al., n.d.). Actuaries increasingly treat longevity as a distinct source of risk, emphasizing the uncertainty surrounding future mortality improvements and their impact on funding ratios and reserve adequacy. In this study, longevity is viewed as the practical outcome of mortality improvement, thereby linking demographic change to the financial obligations of life annuity providers.

Theoretical Review

The Gompertz–Makeham Law of Mortality

The Gompertz–Makeham Law of Mortality, proposed by Benjamin Gompertz (1825) and refined by William Makeham (1860), states that the force of mortality increases exponentially with age. While external mortality causes remain constant, the age-dependent component grows rapidly, explaining higher mortality at older ages. The Lee–Carter model extends this law by incorporating time-varying elements to reflect historical mortality changes. In this study, the law’s relevance lies in identifying when longevity risk becomes significant, particularly when actual mortality improvements exceed expectations and important consideration for annuity businesses (Castellares, Patricio, & Lemonte, 2024).

Empirical Review

Empirical studies on mortality trends and patterns are extensive in developed countries, where rising life expectancy has reshaped pension and annuity systems. Most research applies stochastic or deterministic models, such as the Lee–Carter and Cairns-Blake-Dowd frameworks, to quantify mortality improvements and assess longevity risk (Qiao, Wang & Zhu, 2024; Zheng et al., 2025). These studies generally rely on detailed national mortality data and utilized time-series or cohort analyses to forecast future survival probabilities. Findings consistently reveal that declining mortality increases annuity costs and pension liabilities (OECD, 2014). However, limitations arise from model sensitivity to data quality and assumptions about future improvements.

Regional studies highlight heterogeneity by age and gender. Fong (2015) reported faster female longevity gains, while Ashwin and Scott (2025) and Suzuki (2023) found that late-life mortality decline exerts the highest financial impact on life insurers. In contrast, empirical actuarial research in developing countries remains sparse. Nigerian studies largely emphasize demographic and public health outcomes (National Population Commission & ICF, 2024; Ilori & Akode, 2021), offering limited insight into valuation impacts. This study therefore addresses the gap by applying mortality trend analysis within an actuarial framework tailored to Nigeria’s life annuity market.

3. METHODS

Research Design

The study adopted an ex post facto research design, which is appropriate when a researcher examines existing data to identify patterns, relationships, or trends without manipulating any variables. The design enables the assessment of mortality trends and patterns across age groups and time periods, allowing the researcher to draw inferences about the evolution of survival patterns in Nigeria. Such a design aligns with actuarial practice, where mortality studies often depend on retrospective analyses of historical data to inform future projections and risk assessments.

Source and Nature of Data

The study utilized secondary mortality data which was obtained from the United Nations World Population Prospects (UN WPP) database. The dataset includes age-specific death rates (ASDR) for both males and females in Nigeria, covering multiple five-year periods between 1960 and 2024. The ASDR measures the probability of death within a specific age interval per unit of exposure and provides a robust basis for assessing mortality dynamics over time. The UN WPP data were chosen due to their consistency, international comparability, and long historical coverage, which allow for meaningful trend analysis even in contexts with incomplete national vital registration systems such as Nigeria.

Method of Data Analysis

The data analysis focused on identifying the historical patterns and trends of mortality in Nigeria using the United Nations World Population Prospects (WPP) data (1960-2024). The analysis adopted a quantitative exploratory approach aimed at establishing the direction, magnitude, and variability of age-specific mortality across time, before any formal actuarial modeling. Descriptive and trend analyses were conducted to summarise the distributional characteristics of mortality across ages, sexes, and selected years. Descriptive measures such as the mean, median, standard deviation, skewness, and kurtosis were computed to assess the central tendency, variability, and shape of the mortality rate distribution. The analysis emphasized key reference ages (0, 5, 10, 20, 40, 60, 80, and 100 years) and five-year time intervals to ensure clarity of trend visualization. To capture the temporal dynamics, graphical plots were employed to illustrate the direction and rate of mortality change over time, while comparative tables were used to highlight differences between gender and age groups. This descriptive framework provides an empirical foundation for understanding the evolution of mortality in Nigeria and serves as a baseline for further studies on mortality modeling using statistical models such as the Lee–Carter framework.

4. RESULT

This section presents and analyzes the historical trends and patterns in Nigeria's age-specific death rates (ASDRs) derived from the United Nations mortality database. The analysis focuses on selected years from 1960 to 2020 at five-year intervals to provide a clear picture of the long-term trajectory of mortality dynamics while avoiding the distortion that may arise from year-to-year fluctuations. The descriptive statistics comprising mean, median, standard deviation, and distributional shape are examined to capture the underlying characteristics and variability of mortality across time. This preliminary analysis forms the empirical foundation for assessing changes in mortality experiences and their implications for actuarial modeling, particularly in relation to life annuity valuation reserving in Nigeria.

Table 4.1: Descriptive Statistics of Age-Specific Mortality Rates for selected years

Statistics	Mean	Median	S.D	Minimum	Maximum
1960	0.107	0.232	0.165	0.006	0.739
1965	0.106	0.023	0.163	0.006	0.733
1970	0.102	0.022	0.159	0.005	0.721
1975	0.097	0.019	0.153	0.005	0.698
1980	0.093	0.018	0.149	0.004	0.682
1985	0.093	0.018	0.151	0.004	0.685
1990	0.095	0.019	0.152	0.004	0.686
1995	0.096	0.019	0.153	0.005	0.692
2000	0.095	0.019	0.152	0.004	0.683
2005	0.092	0.016	0.150	0.004	0.668
2010	0.090	0.015	0.148	0.004	0.661
2015	0.090	0.014	0.148	0.004	0.662
2020	0.096	0.015	0.162	0.003	0.763
2024	0.087	0.013	0.146	0.003	0.31

Source: Researcher's Computation using R Output 2025

Table 4.1 presents the descriptive statistics of the age-specific death rates (ASDRs) in Nigeria for selected years between 1960 and 2020. The results reveal a steady decrease in the mean mortality rate from 0.1071 in 1960 to 0.0957 in 2020, reflecting a gradual improvement in overall mortality experience across the country. This downward trend is accompanied by a consistent decline in the median ASDR from 0.0233 to 0.0146, suggesting that mortality improvements were widespread across most age groups rather than being concentrated at a few ages.

The standard deviation of mortality rates declined from 0.1651 in 1960 to approximately 0.1618 in 2020, implying a modest reduction in mortality dispersion across ages. This indicates that mortality risks have become more homogeneous over time which is a pattern consistent with demographic transitions in developing countries where health interventions and living conditions gradually improve. The minimum and maximum values also show a downward shift over time, suggesting that both the lowest and highest mortality experiences have improved.

For actuaries, these patterns signify a progressive reduction in the force of mortality (μ_x), implying increased life expectancy and longevity improvements in Nigeria. Such changes have direct consequences for life annuity pricing and reserving, as lower mortality translates to longer expected payout periods and potentially higher future liabilities for insurers and pension funds. This trend underscores the need to integrate mortality improvement factors into valuation assumptions to ensure that life annuity and pension products remain financially sustainable over the long term. In summary, the descriptive analysis provides preliminary evidence of a consistent, though gradual, improvement in mortality outcomes in Nigeria between 1960 and 2020. Also the relatively smooth decline in mortality also supports the assumption of a systematic time-trend component in mortality modeling, which is often captured in stochastic or time-series-based.

Figures 4.1 and 4.2 show the mortality curves for females and males in Nigeria respectively. The figures display a characteristic U-shape, typical of age-specific mortality patterns across

populations. Mortality rate is highest at birth, declines sharply during childhood and early adulthood, and then increases steadily at older ages. Across all observation years (1960–2020), both charts show a consistent downward trend in mortality experience, indicating steady improvement in survival probabilities over time.

From an actuarial perspective, these improvements suggest progressive mortality improvement factors across different age groups, which are crucial inputs in life table construction and mortality projection. The observed decline in infant and child mortality between 1960 and 2020 implies improved early-life survival probabilities, affecting the expected future life expectancy at birth. For working-age groups, gradual declines in mortality enhance life annuity and pension liabilities, since more individuals survive to retirement and receive payments for longer periods. A notable pattern is the gender differential in mortality as female mortality rates are consistently lower than male rates across all ages and years, especially at working and older ages.

This is consistent with global empirical studies that women exhibit greater longevity than their male counterpart due to biological, behavioral, and lifestyle factors. The implication of this gender disparities for actuaries translates into longer expected annuity payout periods for females and higher pricing margins for female life annuities. Finally, the relative compression of mortality at older ages and convergence of survival trends between 2000 and 2020 suggest a gradual longevity improvement, reinforcing the need for dynamic mortality models in actuarial practice. Ignoring these temporal and gender variations may lead to underestimation of longevity risk and mispricing of pension and annuity products in Nigeria.



Figure 4.1 Mortality Curve Cross Ages for Nigeria (Female)

Source: Output from R (2025)

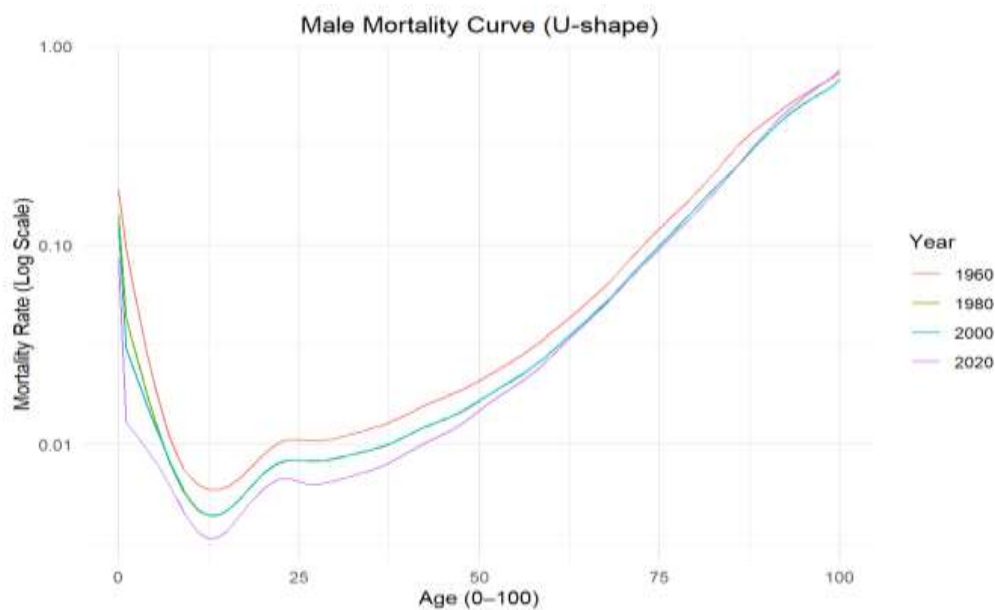


Figure 4.2: Mortality Curve across Ages for Nigeria (Male)

Source: Output from R (2025)

Figure 4.3 shows a steady improvement in life expectancy at birth for both males and females in Nigeria over six decades. Female life expectancy consistently exceeds male life expectancy, with both lines trending upward from around 37 years in 1960 to approximately 57 years (Female) and 55 years (Male) by 2024.

It is observed from the life expectancy trend that there is longevity Improvement as the upward trend reflects a sustained decline in age-specific mortality rates, particularly in early childhood and working-age populations. This implies improved survival probabilities (l_x) and a shift in the mortality curve toward older ages.

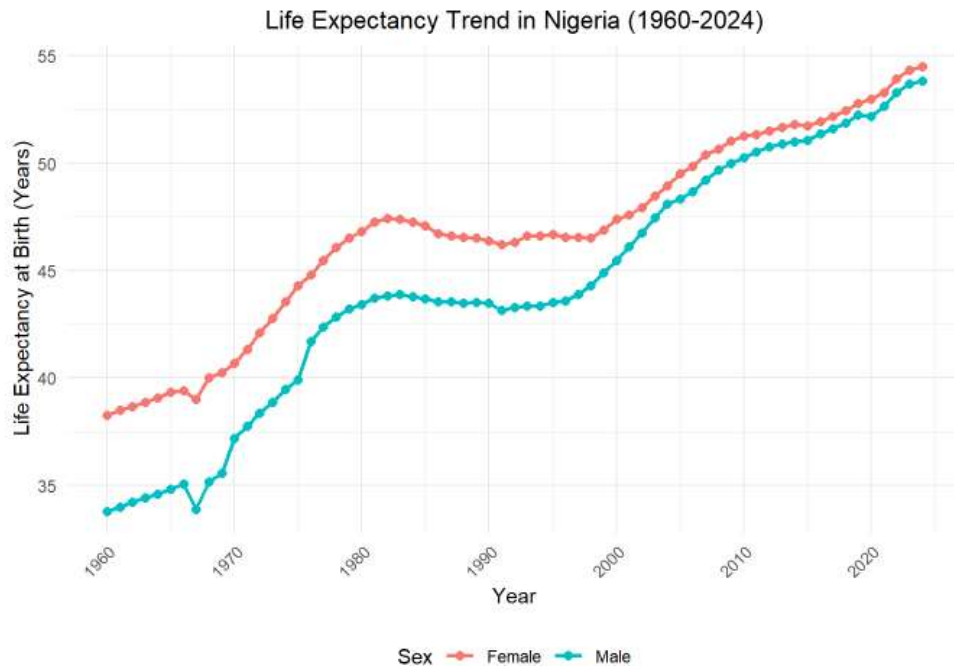


Fig 4.3 Life Expectancy Trend in Nigeria (1960 - 2024)

Source: Output from R

Figure 4.3 highlights an important insight in gender differentials as females maintain a 2 to 3 years advantage in life expectancy throughout the period, indicating lower mortality risk across most age group. The steeper slope from the mid-1990s onward suggests enhanced public health interventions, better access to healthcare, and socioeconomic improvements. Figure 4.3 also reveal that there is greater exposure to longevity risk which is the possibility that retirees live longer than projected which can subsequently strain insurer liabilities and pension fund solvency. The life expectancy trend implies that longer life expectancy leads to higher annuity costs and hence actuaries must revise mortality assumptions and annuity factors to avoid underpricing.

5. DISCUSSION OF FINDINGS

The study analysed Nigeria's historical mortality dynamics (1960-2024) using United Nations data, focusing on the actuarial implications of observed trends. The results show a consistent decline in age-specific death rates, though the pace of improvement varies across age groups and genders. Similar to the findings of Ilori and Akode (2021) and Ogungbenle et al. (2024), the most significant reductions occurred at early childhood ages, reflecting improvements in maternal and child health, immunisation, and general healthcare access. This aligns with the epidemiological transition theory, which posits that mortality declines first occur at younger ages before shifting to older populations.

In contrast, the slower decline in adult and elderly mortality mirrors the persistence of non-communicable diseases and weak geriatric care systems noted by Obiorah (2020). This uneven mortality improvement suggests that increase in life expectancy may not uniformly enhance pension or annuity sustainability which is consistent with the studies of Fong (2015) and OECD (2014), who observed similar actuarial implications in developing countries. Actuaries must therefore incorporate differentials in mortality assumptions by age and gender when projecting liabilities to avoid underestimating longevity risk.

The consistently lower female mortality rates observed across all ages emphasized the global pattern that women generally outlive men (Ashwin & Scott, 2025; Suzuki, 2023). The implication of this outcome for actuaries is that higher annuity reserves and longer payout durations must be factored in for females and gender-sensitive pricing must be considered. Similar gender-based longevity patterns have been incorporated into annuity pricing models in developed countries but remain underutilized in Nigeria's actuarial practice.

Furthermore, the gradual rise in life expectancy, though still below global averages, indicates an emerging longevity risk environment. This supports the assertion by Qiao, Wang and Zhu (2024) that even moderate mortality improvements can significantly affect reserve adequacy and solvency. Hence, without appropriate adjustments in actuarial assumptions, insurers and pension funds in Nigeria may face funding pressure as longevity improves.

Overall, the observed mortality dynamics align with global evidence of demographic transition but reveal limited actuarial integration in Nigeria. While developed economies have more established longevity modeling practices, Nigerian research has only recently begun to incorporate such approaches beyond descriptive trend analysis (Ajijola, Patrick & Chukwuemeka, 2025). This highlights the need to bridge demographic evidence and actuarial application by embedding mortality trends into risk assessment and pricing structures to enhance the financial sustainability of pensions and life annuities in Nigeria.

6 CONCLUSION

The analysis of Nigeria's mortality dynamics from 1960 to 2024 shows a sustained decline in age-specific death rates, with the sharpest improvements occurring at younger ages. This supports earlier findings that public health and maternal - child interventions have driven much of the mortality reduction. However, the slower progress at older ages highlights persistent challenges from non-communicable diseases and limited elderly care systems.

Gender analysis confirms that females experience consistently lower mortality and higher life expectancy than males, reflecting global longevity patterns. Actuarially, this underscores the need for different assumptions in annuity pricing and pension valuation to avoid gender-based underestimation of liabilities.

Overall, while life expectancy in Nigeria has increased steadily, the uneven pace of mortality decline across age and gender groups indicates growing longevity risk for pension and insurance systems. These findings call for more refined actuarial modeling and stronger data-driven monitoring to ensure financial sustainability amid demographic change.

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