ACTUARIAL MODELLING OF RETIREMENT BENEFIT PAYOUT USING MAKEHAM MORTALITY LAW:
A Case Study of Nigerian Federal University Lecturers

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ABSTRACT

This study presents an actuarial analysis of pension sustainability for Nigerian university lecturers under the Contributory Pension Scheme (CPS). Salary progression was modelled using three approaches: a 3-year promotion trajectory, a multiple rates model, and an exponential function. The multiple rates model provides the best fit to the observed stepwise pattern of academic salary growth. Mortality was incorporated using Makeham's law fitted to 2024 UN World Population Prospects data. The resulting sex-specific survival functions confirm a consistent female survival advantage across all ages. Fund accumulation over a 45-year career is projected under Pension Fund Administrator return scenarios ranging from 4% to 20%. Estimated retirement savings ranged from ₦101.71 million to ₦772.79 million, underscoring the dominant influence of investment returns over salary growth on final fund value. At an 8% rate, programmed withdrawals yielded gender-neutral monthly pensions that declined from ₦1.03 million for a 5-year payout period to ₦0.49 million for a 15-year period. In contrast, annuity payments were gender-differentiated and exceeded withdrawal amounts by 57% - 152%, consistently favouring males due to their lower survival probability. These findings demonstrate that annuities outperform programmed withdrawals through pooled mortality credits, while benefit adequacy depends jointly on investment performance, payout period, and sex-specific mortality assumptions, thereby offering actionable guidance for pension administrators and policymakers.

Keywords: Programme Withdrawal Options, Makeham Law, Annuity, Contributory Pension Scheme, Modelling

JEL classification: C61, I150, J11

1. Introduction

Retirement marks a significant phase in life, where individuals stop working due to age, health, or personal reasons. At this stage of life, individuals rely on the savings and investments they have accumulated over time, shifting from earning a steady income to drawing from retirement savings. Adequate retirement planning is essential to ensure financial security and the ability to maintain a comfortable standard of living. Since retirees no longer have an active income, their savings must cover everyday expenses, healthcare, and unforeseen needs. Without adequate planning, retirees may face financial hardships, emphasizing the need for careful financial preparation to avoid stress later in life.

In many African countries, the inadequacy of retirement and pension benefits is a paramount issue that requires thoughtful analysis. Nigeria, in particular, has undergone significant pension reforms aimed at improving financial security for retirees. The Pension Reform Act of 2014 introduced the Contributory Pension Scheme (CPS), where both employees and employers contribute to a pension fund. This system was designed to address the challenges that plagued the previous defined benefit (DB) pension scheme such as the government's inability to meet pension overheads, delays in payments, and corruption. The CPS is overseen by the National Pension Commission (Binuomoyo, 2010).

It is important to clarify the scope of this study from the outset. The analysis focuses specifically on lecturers in Nigerian federal public universities. While the Consolidated University Academic Salary Structure (CONUASS) is uniformly adopted across all federal universities, salary structures and, by extension, pension contributions for academic staff are governed by the National Universities Commission's (NUC) CONUASS. Accordingly, the 2024 CONUASS forms the basis of the salary data employed in this study. University lecturers in Nigeria are required to participate in this pension scheme, and their retirement is generally mandated between the ages of 65 and

70, depending on institutional guidelines (Adegbayi, 2005; Adegbite, 2015). When they retire, they have two primary options for receiving their pension: programmed withdrawals or an annuity. These payout options play a vital role in determining retirees' financial well-being throughout retirement.

Mortality rates are a key factor in retirement planning, particularly when determining how long retirement benefits should last. Actuarial science provides valuable tools for predicting life expectancy and assessing mortality risks, which helps in making informed decisions about retirement savings. Mortality tables and laws, such as Makeham's mortality law, are used to model life expectancy by considering both age-related and non-age-related risks, including lifestyle, health conditions, and environmental factors (Benjamin & Soliman, 1993; Castellares et al., 2022; Cohen et al., 2018).

Actuarial analysis helps retirees make these choices by using models like Makeham's mortality law to predict how long they are likely to live, and ensuring that their retirement savings last throughout their lifetime. By incorporating mortality risks into retirement planning, financial planners can recommend strategies that maximize security and prevent retirees from running out of savings. Annuities are a vital component of retirement planning for ensuring lifelong income. In exchange for a lump sum or regular contributions during an individual's working years, an annuity provides fixed payments at regular intervals, usually for the rest of the policyholder's life. In Nigeria, the Pension Reform Act of 2014 gives retirees the option to purchase a life annuity from a licensed insurance company, offering financial security in retirement. Retirees can also opt for programmed withdrawals, which are designed as structured payments based on their estimated lifespan (Pension Reform Act, 2014).

Annuities offer the advantage of pooling mortality risks across a large group of policyholders, thus providing stability that is not available with traditional investment products such as bonds. Factors influencing the pricing of annuities include applicable discount rates, mortality assumptions, and associated costs. In a study analysing annuity pricing in the UK from 1957 to 2002, Cannon and Tonks (2004a) highlighted that annuities provide relatively fair pricing and a stable income stream, although certain risks persist, particularly for retirees under the Contributory Pension Scheme (CPS).

The choice between a programmed withdrawal and annuity has profound implications for a retiree's financial stability. Those with a higher life expectancy might benefit more from the consistent income provided by annuities, while others may find programmed withdrawals more flexible and suited to their needs. For university lecturers in Nigeria, understanding these options is essential to ensure that retirement savings are sufficient to last a lifetime and prevent financial hardship during their later years (Ibiwoye, 2008).

The adequacy of pre-retirement savings is an important concern for university lecturers in Nigeria, particularly regarding their retirement benefit payout options, such as programmed withdrawal and annuity. While pension schemes are intended to provide financial security during retirement, evidence suggests that many lecturers may face financial challenges upon retirement. This issue is compounded by a volatile economic environment and persistent inflation, which can diminish the value of savings over time. University lecturers play a pivotal role in Nigeria's educational and developmental landscape; however, their financial well-being post-retirement is often neglected. This oversight can lead to inadequate savings, resulting in financial distress, a diminished quality of life, and an inability to sustain a comfortable lifestyle during retirement years. Additionally, the existing pension schemes typically adopt a one-size-fits-all approach that fails to consider individual differences in career length, salary progression, and personal financial objectives, further exacerbating the issue.

There is a paucity of comprehensive actuarial models for assessing retirement benefit payout options for lecturers in Nigerian tertiary institutions. The challenge is twofold: limited application of the Makeham mortality law and the absence of occupational mortality data for Nigerian academic staff. Consequently, existing studies rely on national life tables, overlooking the distinct economic, demographic, and occupational characteristics of lecturers. This undermines forecasting accuracy and effective financial planning, increasing the risk of premature depletion of retirement savings.

The core problem is that, despite pension reforms, no comprehensive actuarial framework currently exists to evaluate whether the programmed withdrawal and annuity options available to Nigerian public university lecturers provide adequate retirement income. This is especially true when lecturer-specific salary progression and realistic, gender-specific mortality

experience are considered. Addressing this gap requires models that can identify deficiencies in the current pension structure, assess the impact of economic variables on retirement payouts, and inform strategies that improve the financial preparedness of lecturers as they transition into retirement.

Hence, the main objective of this study is to develop and apply an actuarial framework, based on Makeham's mortality law, to evaluate the retirement benefit payout options programmed withdrawal and life annuity available to male and female lecturers in Nigerian public universities, using the 2024 NUC-approved consolidated salary structure. Specifically, the study aims to: (i) model the salary progression of a representative university lecturer from Assistant Lecturer to Professor under multiple growth-rate assumptions; (ii) fit Makeham's mortality law to United Nations mortality data to derive gender-specific survival probabilities and life expectancy, and (iii) compute the expected present value of annuities and the corresponding monthly pension under both payout options.

This study contributes to the existing literature in several ways. First, unlike prior studies that examine retirement benefit payouts in the Nigerian pension space in general terms, this paper develops a lecturer-specific actuarial model that explicitly incorporates the exponential, rank-based salary progression that characterizes the academic career path. Second, it integrates Makeham's mortality law rather than the more commonly used Gompertz's law or standard mortality tables into the valuation of both programmed withdrawal and annuity options, providing a more realistic representation of age-dependent and age-independent mortality risks. Third, by presenting gender-disaggregated results, the study clarifies how differences in life expectancy between male and female lecturers translate into disparities in monthly pension income and replacement rates, an issue that remains underexplored in the Nigerian context. Collectively, these contributions will provide policymakers, pension fund administrators, and university management with an empirically-grounded basis for assessing and improving the design of retirement benefit options for academic staff in Nigerian public universities.

The remainder of this paper is organized as follows: section 2 reviews the relevant literature on retirement benefit systems, payout options, and mortality modelling; section 3 describes the research methodology, including the data, Makeham's mortality law, and the actuarial models for programmed

withdrawal and annuity valuation; section 4 presents and discusses the results; and section 5 concludes the paper with policy implications and directions for future research.

2. Literature Review

2.1 Retirement benefit systems in Nigeria

The global shift from Defined Benefit (DB) to Contributory Pension Scheme (CPS) represents one of the most significant transformations in social protection systems over recent decades, driven by demographic ageing, rising life expectancy, and fiscal pressures on governments (Bodie et al., 1985; Etuk, 2022; Odia, 2012). While this transition has improved long-term financial sustainability, it has simultaneously transferred investment and longevity risks to retirees, creating new challenges for retirement income adequacy that are particularly acute in developing economies characterized by macroeconomic instability and underdeveloped financial markets (Blake et al., 2011; Cairns et al., 2006).

Nigeria's pension reform through the Contributory Pension Scheme (CPS), established by the Pension Reform Act 2004 and strengthened in 2014, represents one of sub-Saharan Africa's most comprehensive pension transformations. The reform replaced a chronically underfunded DB system characterized by delayed payments, weak governance, and significant unfunded liabilities (Akalonu & Ipinyomi, 2015; Balogun, 2006). Under the CPS, mandatory monthly contributions (8% employee, 10% employer) are directed into individually-owned retirement savings accounts (RSAs) managed by licensed pension fund administrators under the National Pension Commission (PenCom) supervision. While this framework has substantially improved pension administration and accountability, concerns regarding retirement income adequacy persist, with studies demonstrating that RSA balances are highly sensitive to salary progression, contribution density, investment performance, inflation, and career interruptions (Ibiwoye & Agboola, 2018; Ibiwoye & Ajijola, 2012).

Recent international evidence underscores that the CPS faces increasing pressure from population ageing and extended retirement durations, necessitating careful integration of contribution rates, investment returns,

longevity assumptions, and decumulation strategies (Mitchell & McCarthy, 2015). For Nigerian university lecturers, these challenges are compounded by unique employment characteristics: long service periods, delayed promotion patterns, mandatory retirement extending to 70 years for professors, and salary progression tied to academic ranks rather than annual increments.

Persistent inflation and macroeconomic volatility further complicate retirement adequacy assessment in Nigeria. Recent studies report that although pension fund assets have grown substantially under the CPS, retirees' ability to maintain adequate consumption throughout retirement remains uncertain, particularly for workers with irregular salary growth or limited contribution histories (Obasa, 2022). This reinforces the argument that pension adequacy should incorporate replacement rates, expected retirement duration, and mortality-adjusted payout strategies rather than relying solely on accumulated balances.

2.2 Programmed withdrawal versus life annuity

The decumulation phase has attracted increasing attention in pension economics and actuarial science, as the method of converting accumulated pension wealth into retirement income fundamentally determines retirees' long-term financial security (Cannon & Tonks, 2004b). Under the Nigerian CPS, retirees may select programmed withdrawal (PW), administered by PFAs, or purchase a life annuity from licensed insurers. These options differ fundamentally in their treatment of investment risk, longevity risk, flexibility, inheritance rights, and payment certainty (Sogunro & Oke, 2022a).

Programmed withdrawal allows retirees to retain RSA ownership while receiving periodic payments calculated using actuarial assumptions regarding life expectancy, expected investment returns, and remaining account balance. This option offers flexibility and inheritance opportunities but exposes retirees to investment risk, inflation risk, and longevity risk particularly as life expectancy improves globally (Ibiwoye & Ajijola, 2012). In contrast, life annuities transfer longevity and investment risks to insurers through mortality pooling, providing guaranteed lifetime income (Akpan, 2017). Theoretical and empirical research consistently identifies life annuities as among the most effective instruments for managing longevity risk (Cannon & Tonks, 2004a),

yet behavioural factors, the "annuity puzzle" contribute to low voluntary annuitization in many countries due to preferences for liquidity, flexibility, and bequest motives (Benartzi et al., 2011).

Within Nigeria, empirical evidence comparing programmed withdrawal (PW) and life annuity remains relatively limited. Early actuarial investigations demonstrated that mortality assumptions significantly influence retirement benefit valuation and the sustainability of retirement income (Ibiwoye & Ajijola, 2012). Subsequent studies further showed that many retirees may experience inadequate retirement income unless investment performance and contribution histories improve substantially (Sogunro & Oke, 2022a).More recent evidence indicates that the relative attractiveness of programmed withdrawal and life annuity depends on prevailing economic conditions, interest rates, and retirees' longevity expectations (Oyelade et al., 2025). However, most Nigerian studies continue to employ simplified actuarial assumptions with limited occupation-specific modelling, despite evidence that differences in salary progression, retirement age, and mortality characteristics across professions can significantly influence pension adequacy and retirement benefit outcomes.

2.3 Mortality modelling and Makeham's Law

Mortality modelling constitutes a cornerstone of actuarial science, providing the quantitative framework for estimating survival probabilities, life expectancy, annuity values, and pension liabilities (Pitacco et al., 2009). Accurate mortality models are fundamental to ensuring retirement benefits remain financially sustainable while providing adequate lifetime income. Makeham's law, extending Gompertz's exponential model by introducing an age-independent mortality component, has become one of the most widely-adopted mortality laws in actuarial science (Gompertz, 1825; LeMaire et al., 1990; Makeham, 1860). The principal advantage lies in distinguishing mortality arising from biological ageing from that resulting from external causes, a distinction particularly important when modelling working populations with varying occupational, environmental, and socio-economic risk exposures.

While more sophisticated stochastic models have been developed, including the Lee-Carter model (Lee & Carter, 1992), and the Cairns-Blake-Dowd model (Cairns et al., 2006), classical parametric models such as Makeham's law remain relevant due to their transparency, computational efficiency, and ease of interpretation, particularly in actuarial applications involving pension pricing and annuity valuation (Olivieri & Pitacco, 2009).

In developing countries, including Nigeria, mortality modelling presents additional challenges due to limited comprehensive mortality databases and demographic patterns differing considerably from developed economies (Ibiwoye & Ajijola, 2012). Previous Nigerian pension studies have generally relied on standard mortality tables or simplified actuarial assumptions without detailed calibration using local demographic data, potentially introducing systematic errors into annuity valuation and retirement income estimation (Amiens & Abusomwan, 2020). Research in Nigeria on classical models – Gompertz and Weibull – have been investigated et al., 2025). The present work discovered that the Gompertz model generally predicted higher annuity payouts for males, while the Weibull model showed slight increases for females.

2.4 Gender disparities in retirement planning

Gender has emerged as a critical dimension in retirement planning, with differences in labour market participation, earnings trajectory, life expectancy, and mortality patterns significantly influencing retirement income adequacy (Butler, 2012). The female longevity advantage is consistently observed across virtually all populations, with women exhibiting lower mortality rates and longer life expectancy than men. From an actuarial perspective, for the same accumulated retirement fund, female retirees generally receive lower periodic annuity payments than males because insurers spread pension capital over longer expected lifetimes (Luciano et al., 2016). This actuarial equivalence principle has generated considerable debate regarding gender equity, as women may receive lower monthly pensions despite similar accumulated savings. A recent study examined the effect of human capital development on maternal and under-five mortality rates in Nigeria using the health demand (Oburuta et al., 2026). The study argued that health and education are fundamental components of human capital and play significant roles in improving health

outcomes. According to Grossman's model, health is viewed as a form of capital that depreciates over time, with the rate of depreciation increasing as individuals age.

3. Methodology

3.1 The Makeham model

In actuarial science, the force of mortality under Makeham's law is defined as (Castellares et al., 2022):

$$\mu_x = A + Bc^x \tag{1}$$

where:

μ(x)	=	force of mortality at age xxx
A	=	age-independent mortality component
B	=	scale parameter associated with age-dependent mortality
c	=	exponential growth parameter governing the rate at which mortality increases with age (c>1)

The mortality μ(x) is obtained from United Nations data.

The parameters A, B and c were estimated separately for males and females using nonlinear least squares regression in MATLAB (Rasaki et al., 2023). The estimation procedure identified the parameter values that minimize the differences between the observed mortality rates and those predicted by the Makeham model. Specifically, the objective was to minimize the weighted sum of squared residuals, $min \sum_x w_x[\mu_x - (A + Bc^x)]^2$, where μ_x denotes the observed mortality rate at age x, $A + Bc^x$ is the fitted mortality rate, and w_x is the weight assigned to each age.

Initial parameter values of A = 0.005, B=0.001, and c =1.08 were provided to facilitate convergence of the optimization algorithm. Parameter bounds were also imposed to ensure biologically meaningful estimates, with $A \geq 0$, $B \geq 0$, and $c > 1$, reflecting the exponential increase in mortality with age. The optimization was performed using MATLAB's **lsqcurvefit** function, which employs a nonlinear least-squares algorithm to iteratively estimate the parameters until the difference between the observed and fitted mortality rates

is minimized. A weighted fitting approach was adopted to improve the stability of the estimates across the age range. Survival function for the study was calculated using (Benjamin & Soliman, 1993):

$$l_{x+1} = l_x e^{-\mu_x} \tag{2}$$

then the survival function l_x was iteratively computed.

3.2 Total accumulation

The total savings of a lecturer with a single salary escalation and interest rate is given by (Sogunro et al., 2019; Sogunro & Oke, 2022a):

$$F = \frac{C\Gamma}{m} \sum_{k=1}^{M} (1+e)^{\frac{k}{m}} (1+i)^{\frac{M-k}{m}} \tag{3}$$

where:

C is the yearly contribution,

Γ is the summation of employee and employer contribution (18%)

m is month in a year

$M = m(y - x)$.

y and x are the year of service and year the lecturer started to lecture in the University.

The payments are adjusted for growth e and are further accumulated by applying an interest rate per period. The interest rates insurance (interest) rate adopted in this study was based on the average interest rate reported in a previous study that investigated the effect of capital account openness on the relationship between interest rate policy and exchange rate volatility in Nigeria (Musa & Sanusi, 2020).

Equation (3) is modified to cater for several growths and interest rates within the service years of the lecturer. Hence the accumulated contribution is given as (Oyelade et al., 2025):

$$F_{U,P} = \frac{C_1\Gamma}{m}\left[\sum_{k=1}^{M_1}(1+e_1)^{\frac{k}{m}}(1+i_1)^{\frac{M-k}{m}} + \sum_{k=M_1}^{M_2}(1+e_2)^{\frac{k}{m}}(1+i_2)^{\frac{M-k}{m}}\right] + \frac{C_2\Gamma}{m}\left[\sum_{k=M_2}^{M_3}(1+e_3)^{\frac{k}{m}}(1+i_3)^{\frac{M-k}{m}}\right] \tag{4}$$

$$e = \begin{cases} e_1 & 25 \le e \le 35 \\ e_2 & 34 \le e < 51 \\ e_3 & >50 \end{cases} \tag{5}$$

3.3 Actuarial accumulation

Given a survival model, with survival probabilities p_x, we can construct the life table for the model from some initial age x_0 to a maximum age ω. Survivor probabilities kp_x can be defined as (Abdul Aziz, 2020):

$${}_k p_x = \frac{l_{x+t}}{l_x} \tag{6}$$

where: l_x is the number of individuals alive at age x in a life table and l_{x+t} is the number of individuals alive at age $(x + k)$ from the same cohort tracked by the life table.

It reflects the portion of the population that survives to age. Expected present value (EPV) of the annuity is the sum of the expected values of the individual (David et al., 2009; Promislow, 2011; Wilders, 2020):

$$\ddot{a}_x = 1 + vp_x + v^2\,{}_2 p_x + v^3\,{}_3 p_x + \ldots\ldots\ldots \tag{7}$$

that is (David et al., 2009)

$$\ddot{a}_x = \sum_{k=0}^{\infty} v^k\,{}_k p_x \tag{8}$$

where: v is the discounting, which is expressed as:

$$v = \frac{1}{1+i} \tag{9}$$

and i is the effective rate of interest.

The monthly life annuity due model that makes a payment at the beginning of every month is expressed as (Hopkins et al., 2002)

$$\ddot{a}_x^{(m)} \approx \ddot{a}_x - \frac{m-1}{2m} \tag{10}$$

3.4 Data sources

Appendix 1 presents the salary scale for academic staff in Nigerian federal universities, based on salary information provided by the National Universities Commission (NUC) to Nigerian universities in 2024. Using this salary structure, the study considers two employees, one male and one female, who joined the Nigerian university system at the age of 25 and retired at 70, the statutory retirement age for professors. Our representative employees began their careers as Assistant Lecturers and spent three years in that role before being promoted to the next level, following the standard progression timeline for academic staff. It is assumed that they spent three years at each academic rank, from Assistant Lecturer to Professor.

The mortality data relied on secondary data from credible and internationally-recognized sources. Mortality and life expectancy data were obtained from the United Nations Department of Economic and Social Affairs, which provides standardized and reliable demographic indicators (Ajijola et al., 2025; Oyelade et al., 2026). These data sources contain comprehensive mortality rates, life tables, and life expectancy trends for Nigeria across multiple decades. These mortality data were used in sub section 3.2 to model the Makeham constants.

4. Results and Discussion

4.1 Estimation of salary progression

Figure 1 shows the expected annual salary amount (in millions) over a span of 45 years, based on different salary growth models. The actual salary progression for a lecturer advancing from Assistant Lecturer to Professor is represented by the '3-Year Promotion' calculation based on the assumption of our representative staff employee spending three years on a level for each grade from Assistant Lecturer, Lecturer II, Lecturer I, Senior Lecturer, Associate Professor to Professor cadre. The 'Multiple Rates' model depicts periodic

variations in salary increments based on our model for the entire period of service of the lecturer. Both curves demonstrate sharp salary growth after 30 years, corresponding to the promotion from Lecturer I to Senior Lecturer. The model peaks at the Professor position, where the salary plateaus, indicating no further increments in this role. This current model of multiple rates agrees well with the actual salary of the lecturer who started teaching at 25 years and retired at age 70 years. On the other hand, the 'Exponential Function' model, which attempts to represent the salary increments of a university lecturer, does not adequately capture the actual progression (Ibiwoye & Ajijola, 2012). The continuous, gradual increase shown by the exponential model fails to reflect the significant step-changes that occur with promotions within the academic hierarchy.

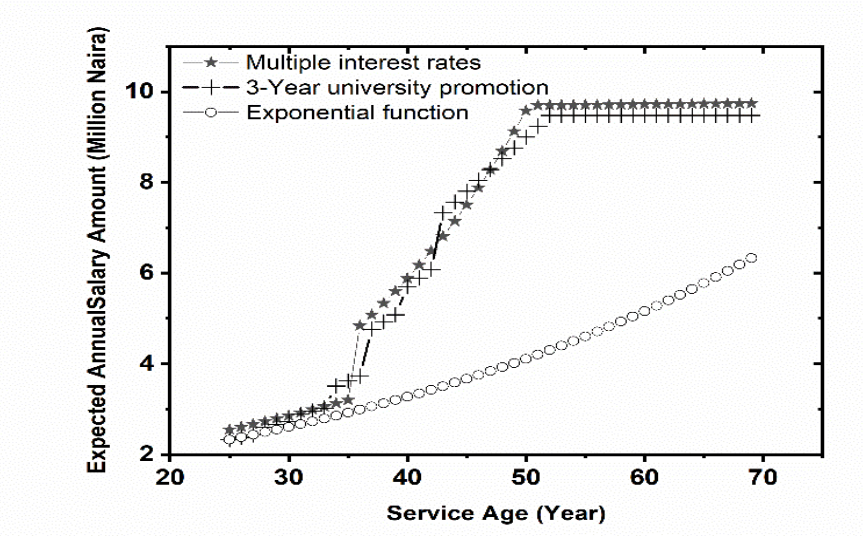

Figure 1. Expected Annual Salary amount of a University Lecturer in Nigeria University
Source: Authors' computation, 2026

4.2 Makeham mortality model

The estimation of Makeham's constants for males and females in Nigeria is based on mortality data from the United Nations World Population Prospects (UN WPP) 2024 life tables. The dataset is structured at single-year age intervals, providing detailed age-specific mortality information from birth

through age 100; however, the Makeham fitting was restricted to ages 20–100, excluding the infant- and childhood-mortality range where mortality declines rather than rises, since Makeham's law assumes a monotonically increasing hazard with age.

Figure 2 presents the central mortality rates (nMx) derived from the 2024 UN WPP data for males, together with the Makeham-fitted curve. The observed data show mortality rising from approximately 0.0055 at age 20, remaining relatively flat through the early-adulthood range to about age 40–45, before increasing steadily thereafter to roughly 0.55–0.6 by age 100. The Makeham-fitted curve, by contrast, starts markedly lower (near 0.0014 at age 20) and rises in an approximately straight line on the log scale, crossing the observed data around age 45–50. From that point onward the fitted curve tracks the observed rates closely through age 100, indicating that Makeham's Law captures the senescent (age-related) component of mortality well but underestimates mortality in early adulthood, where the flatter, largely accident- and external-cause-driven mortality pattern is not well represented by the model's purely exponential form. Figure 3 shows the equivalent fit for females. The female UN WPP data follow the same general shape as the male data, a relatively flat mortality rate through early adulthood followed by a steady rise with age, but sit consistently below the male curve for most of the age range, consistent with the well-documented female survival advantage, before the two sexes converge toward similarly elevated mortality by the oldest ages (Oyelade et al., 2026). As with the male fit, the Makeham curve for females underestimates mortality at younger ages and aligns closely with the observed data from roughly age 50 onward.

For both sexes, the fitted parameters are: males, $A = 0.00955$, $B = 0.00082$, c = 0.080437; females, $A = 0.00132$, $B = 0.00037$, $c = 0.08856$. The substantially lower A and B values for females reflect their lower background and age-dependent mortality relative to males, while the marginally higher C indicates a slightly steeper proportional rate of increase with age, though this does not overturn the female mortality advantage evident across most of the observed range. This method follows the principle used to calculate the parameters for Gompertz Makeham (Hussain et al., 2025). These sex-specific estimates provide the basis for the subsequent survival and annuity calculations, offering a quantitative foundation for actuarial risk assessment

tailored to the Nigerian population, while the systematic underestimation at younger ages is noted as a limitation of the pure Makeham form for this dataset.

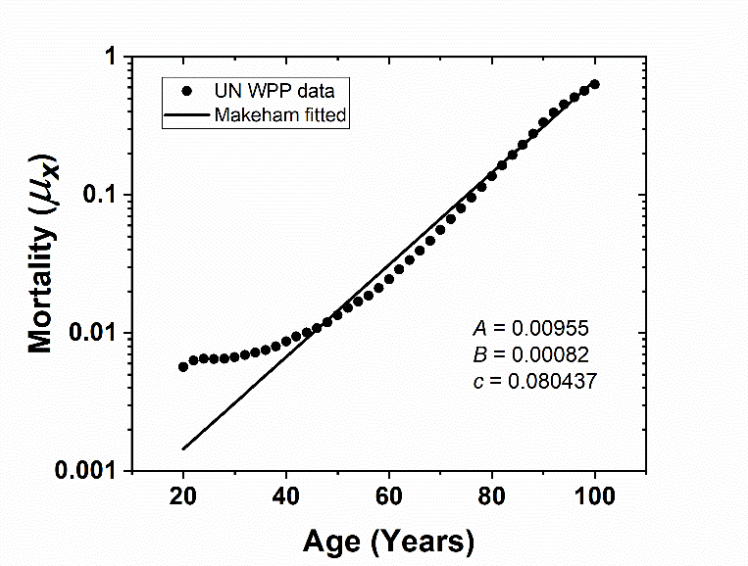

Figure 2. Central mortality *m(x)* vs. Age for Males

Source: Authors' computation, 2026

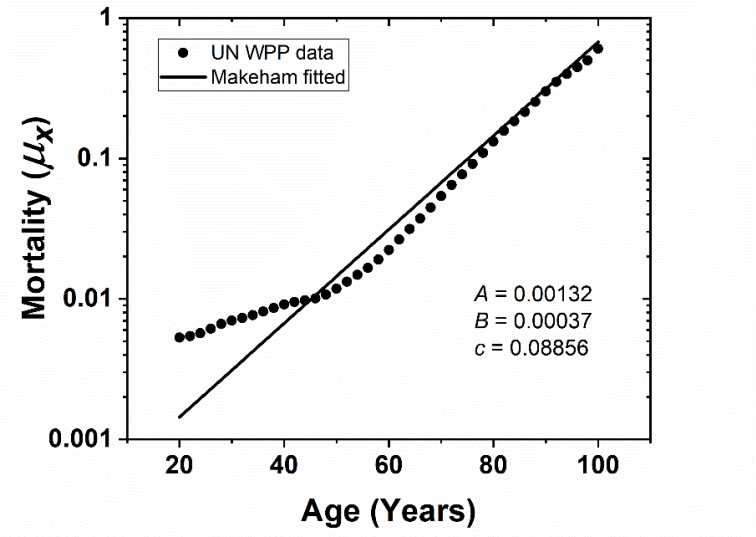

Figure 3. Central mortality *m(x)* vs. Age for Females

Source: Authors' computation, 2026

4.3 Survival analysis

The survival function plot compares the probability of survival by age for males and females in Nigeria (Figure 4). It shows the likelihood of male and female survival as a function of time, beginning in year 70 and continuing until year 100. With a 100% chance of survival at the beginning, the survival probability for both gender starts at 1.0 and progressively drops over time. The females generally have a higher survival rate than males at all ages based on Makeham's constant, with their curve consistently lying above the male curve. Overall, the plot highlights that females tend to live longer than males, with mortality increasing significantly in older age.

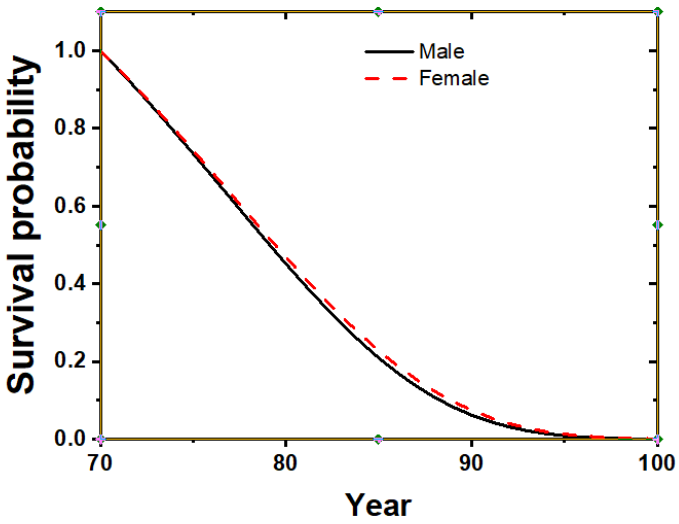

Figure 4. Survival functions for Male and Females in West Africa

Source: Authors' computation, 2026

4.4 Accumulation of retirement fund

The Nigerian pension industry sustained its growth momentum in Q1 2025, underpinned by favourable macroeconomic indicators, enhanced regulatory compliance, and consistent investment returns (National Pension Commission, 2025). Table 1 presents the average returns on investment (ROI) for Retirement Savings Account (RSA) Fund Categories I–V over the 2024/2025 period, which stood at 4.262% and 4.342%, respectively (National Pension Commission, 2025). The lower of these average values (4.262%) serves as the

baseline accumulation rate for projecting the retiree's expected savings, with the sensitivity analysis extending across a range of 4% to 20% to capture potential variability in investment performance under different economic conditions.

Table 1. RSA Retiree Funds: Major Sources of Portfolio growth (Q4 2024/Q1 2025)

Fund	Q4 2024 (%)	Q1 2025 (%)
Fund I	5.13	4.91
Fund II	4.44	4.33
Fund III	3.82	3.83
Fund IV	3.56	3.64
Fund V	4.36	5

Source: Report of National Pension Commission, 2025

Table 2 presents the accumulation of funds in a university lecturer's retirement savings account over a 45-year career under varying salary growth and interest rate scenarios. The salary growth rates, $i_1, i_2,$ and i_3, are held constant at 2.3%, 5%, and 0% respectively, across all cases. The 0% growth rate reflects the period when the lecturer has served at the professorial cadre for more than ten years, after which the salary remains constant until retirement. This increase in salary is assumed to be constant for all lecturers. Conversely, the interest rates, $e_1, e_2,$ and e_3, are varied across three scenarios, ranging from 4% to 20%. This is consistent with the expected Pension Fund Administrator (PFA) investment returns, reflecting the range of performance typically observed in the Nigerian pension industry.

Table 2. Accumulation of Funds in the Retirement Savings Account at differing rates of interest from 10 to 20%

Duration	Accumulation (Million)	Salary growth (%)			Interest rate (%)		
45 years	101.71	$i_1 = 2.3$	$i_2 = 5$	$i_3 = 0$	$e_1 = 4$	$e_2 = 6$	$e_3 = 10$
45 years	242.14	$i_1 = 2.3$	$i_2 = 5$	$i_3 = 0$	$e_1 = 5$	$e_2 = 10$	$e_3 = 15$
45 years	772.79	$i_1 = 2.3$	$i_2 = 5$	$i_3 = 0$	$e_1 = 7$	$e_2 = 15$	$e_3 = 20$

Source: Authors' computation, 2026

In the first scenario, with relatively moderate interest rates ($e_1 = 4\%, e_2 = 6\%$, and $e_3 = 10\%$), the accumulated retirement fund amounts to ₦101.71 million. The second scenario, featuring increased interest rates ($e_1 = 5\%, e_2 = 10\%$, and $e_3 = 15\%$), yields a total accumulation of ₦242.14 million, representing a 138% increase over the first scenario. The third scenario, with the highest interest rates ($e_1 = 7\%, e_2 = 15\%$, and $e_3 = 20\%$), produces the most significant fund accumulation of ₦772.79 million, an increase of over 650% compared to the first scenario. These findings demonstrate that interest rate differentials exert a dominant influence on retirement savings accumulation. Even with constant salary growth, variations in PFA returns alone account for substantial differences in the final fund value, ranging from ₦101.71 million to ₦772.79 million. The compounding effect over a 45-year career amplifies the impact of modest differences in annual returns, underscoring the critical importance of PFA selection and long-term investment performance in retirement planning. These results reinforce the strategic relevance of the Contributory Pension Scheme (CPS) as a framework for retirement security in Nigeria, while highlighting the need for contributors to evaluate PFA performance histories and adopt informed fund management strategies.

In accordance with Act No. 4, Part XII of the 2014 Nigeria Pension Act and guidelines issued by the Nigeria Pension Commission, it is assumed that up to 50% of an employee's accumulated contribution in their Retirement Savings Account is used to purchase either a monthly life annuity or a programmed monthly withdrawal upon retirement.

4.5 Programme withdrawal /annuity

For this work, the first interest rate of 4%, 6%, and 10%, which is the present average a PFA administrator pays their customer would be used for the programme withdrawal and annuity for male and female staff. Fifty percent of the sum is ₦50,854,560.80. Two key factors are important when choosing pension withdrawal options after receiving the lump sum in the reformed pension system: the investment rate and the duration over which the retiree wishes to collect their benefits. Table 3 provides computations based on various investment rates and withdrawal periods.

Table 3: Analysis for the monthly pension receivables in Programme Withdrawal options

Interest Rate (%)	5 Years (million)	10 Years (million)	15 Years (million)
8	1.03	0.62	0.49
10	1.08	0.67	0.55
16	1.24	0.85	0.75

Source: Authors' computation, 2026

Table 3 analyses monthly pension receivables under the Programme Withdrawal option across interest rates of 8%, 10%, and 16%, and payout durations of 5, 10, and 15 years. The results show that monthly payments decrease as payout duration lengthens, while higher interest rates consistently increase monthly receivables (Sogunro & Oke, 2022b). For instance, at 8%, payments range from ₦1.03 million (5 years) to ₦0.49 million (15 years), while at 16%, the range is ₦1.24 million to ₦0.75 million. The sensitivity analysis reveals that a doubling of the interest rate from 8% to 16% increases monthly pension by 20.4% over a 5-year period and 53.1% over a 15-year period, demonstrating the compounding effect of higher returns over longer durations. These findings underscore the trade-off between monthly income adequacy and income longevity, providing critical insights for retirees in selecting appropriate Programme Withdrawal options. The analysis further emphasizes the importance of PFA performance in determining retirement income outcomes under the Contributory Pension Scheme.

In terms of annuity for life, the gender of the lecturer plays an important role. From equation (9), the survivor probabilities greatly affect the EPV value for males and females. Hence the monthly annuity payments for the male and the female are given in Table 4.

Table 4: Monthly annuity payment

Duration	Insurance rate (%)	Male (million	Female (million
5 years	8	1.76	1.62
10 years	8	1.56	1.39

Source: Authors' computation, 2026

Table 4 presents the annual annuity payments for 5-year and 10-year payout periods at a fixed insurance rate of 8%. The results reveal that both the payout duration and the retiree's gender influence the annual annuity amount. For the 5-year payout period, male retirees receive an annual annuity of ₦1.76 million, while female retirees receive ₦1.62 million. When the payout period is extended to 10 years, the annual annuity decreases to ₦1.56 million for males and ₦1.39 million for females. The higher annuity payments received by males across both payout periods are consistent with actuarial principles and mortality modelling. Since females generally have a higher life expectancy than males, the same retirement fund is expected to provide payments over a longer period. Consequently, female retirees receive lower annual annuity payments than their male counterparts. This gender difference reflects the mortality assumptions commonly adopted in life annuity pricing and pension valuation.

The results also demonstrate that increasing the payout period from 5 to 10 years reduces the annual annuity payment for both genders. This reduction occurs because the accumulated retirement fund is distributed over a longer payment horizon, resulting in smaller annual benefits. Although the insurance rate remains constant at 8% for both payout options, the longer payment duration has a greater influence on the annual annuity amount than the interest rate. Therefore, retirees who select a shorter payout period receive higher annual payments, whereas those choosing a longer payout period receive lower annual payments spread over more years.

These findings are consistent with established actuarial theory and published studies on life annuities, which demonstrate that periodic annuity payments are primarily determined by three factors: the accumulated retirement balance, the assumed interest (discount) rate, and the annuitant's expected remaining lifetime. Studies such as those by Dickson, Hardy, and Wilders (David et al., 2009; Wilders, 2020) similarly report that longer payment periods and greater life expectancy reduce the periodic annuity income, while higher discount rates tend to increase annuity payments, all else being equal.

At the 8% rate, the two withdrawal options exhibit markedly different payout structures. For programme withdrawal, monthly receivables decline with duration from ₦1.03 million (5 years) to ₦0.62 million (10 years) to ₦0.49

million (15 years) and are independent of retiree gender, since this option amortizes the lump sum over a fixed, guaranteed term without reference to survival probability. The annuity option, by contrast, is gender-differentiated: at 8%, male retirees receive ₦1.76 million over 5 years and ₦1.56 million over 10 years, compared with ₦1.62 million and ₦1.39 million for females respectively. The male–female gap widens with duration (8.0% at 5 years versus 10.9% at 10 years), reflecting the compounding effect of the mortality differential between sexes over longer payment horizons (Table 5).

Table 5: Comparison of withdrawal and annuity option

Duration	Programme Withdrawal	Annuity (Male)	Annuity (Female)
5 years	₦1.03m	₦1.76m (+70.9%)	₦1.62m (+57.3%)
10 years	₦0.62m	₦1.56m (+151.6%)	₦1.39m (+124.2%)

Source: Authors' computation, 2026

Across both duration bands, the annuity yields higher periodic payments than programme withdrawal for both sexes. This is consistent with the underlying actuarial mechanics: programme withdrawal discounts the lump sum solely by the time value of money, guaranteeing payment for the full term, irrespective of survival, whereas the annuity divides the lump sum by the sum of discounted survival probabilities, a strictly smaller denominator. The resulting mortality-credit effect, whereby funds released by non-surviving annuitants are redistributed to survivors, allows the annuity to sustain higher periodic payments than a comparable fixed-term withdrawal. This premium widens with duration, as the mortality-credit effect compounds over longer horizons while programme withdrawal offers no corresponding offset. These results illustrate a fundamental trade-off in retirement income design: programme withdrawal provides lower but certain periodic income, together with a residual balance payable to beneficiaries in the event of the retiree's death, whereas the annuity provides materially higher periodic income priced on sex-specific mortality assumptions, at the cost of forfeiting residual value should death occur before the annuity term or the annuitant's remaining lifetime is exhausted. The findings reinforce the centrality of gender-specific mortality assumptions in annuity pricing and underscore the need for retirees to weigh

income adequacy against income security when selecting between these options.

The comparison between programmed withdrawal and life annuity reveals fundamental differences in retirement income provision. Consistent with financial theory, programmed withdrawal payments decrease as the payout period lengthens, since a fixed retirement balance must be distributed over more years (Sogunro et al., 2019). Higher investment returns partially offset this reduction by increasing investment earnings during retirement.

Life annuity payments exhibited clear gender differences, with male retirees receiving higher periodic payments than females despite identical accumulated retirement savings. This outcome is entirely consistent with actuarial pricing principles, whereby annuity payments depend on expected future survival. Since female retirees are expected to live longer, their accumulated retirement savings must finance a greater number of future payments, resulting in lower annual annuity benefits. The present study extends these findings by providing empirical estimates based on Nigerian mortality experience rather than relying on foreign mortality tables, thereby improving the relevance of annuity valuation for Nigerian retirees.

One of the most significant findings of this study is that life annuities consistently generated higher periodic retirement income than programmed withdrawal for both male and female retirees. This result supports the actuarial theory of mortality credits, whereby funds released by deceased annuitants are redistributed among surviving members of the annuity pool, allowing insurers to offer higher periodic benefits than can be achieved through individual drawdown arrangements (Owadally et al., 2021; Sogunro & Oke, 2022a). Although programmed withdrawal remains the dominant retirement option among Nigerian retirees because of its flexibility and the possibility of leaving residual balances to beneficiaries, the present findings indicate that this preference may come at the expense of substantially lower retirement income. This observation has important policy implications for retirement counselling in Nigeria. Pension fund administrators should provide clearer information regarding the long-term financial consequences of each payout option so that retirees can make informed decisions based on their health status, family circumstances, and income requirements.

From a policy perspective, the study demonstrates that improving retirement adequacy under Nigeria's Contributory Pension Scheme requires more than increasing contribution rates alone. Pension outcomes are jointly determined by salary progression, long-term investment performance, mortality experience, and the retirement payout option selected. Consequently, actuarial models used for retirement planning should incorporate country-specific mortality assumptions together with realistic investment return scenarios to produce reliable retirement income projections. Such an integrated approach would improve pension planning, enhance retirement security, and support evidence-based policy decisions by the National Pension Commission (Pension Commision, 2014).

5. Conclusions

In this study, the salary scale approved by the Nigerian government served as a benchmark to project the estimated accumulated funds for the entire lifetime of a lecturer in a Nigerian university, along with the contributions made to the pension fund administrator (PFA). The actual interest rate offered by the PFA significantly impacts the eventual benefits that employees will collect at the end of their service years in the university. Using Makeham’s constants for Nigeria, mortality rates for both males and females were calculated. The analysis indicated that the program withdrawal option, which is predominantly utilized by retirees, provides fewer incentives compared to the annuity option. Furthermore, the mortality function for females leads to lower payouts for female retirees compared to their male counterparts, even when both receive the same benefits at the conclusion of their service years.

While this study provides a robust actuarial framework for assessing pension sustainability among Nigerian university lecturers, several simplifying assumptions constrain the generalizability of the results and point to clear directions for future research. First, the model assumes that pension contributions are remitted to the pension fund administrator (PFA) on a strictly monthly basis, with the stated interest rate taking effect immediately and consistently over the entire contribution period. In practice, contribution remittances may be delayed, interrupted, or subject to administrative lags, and PFA returns fluctuate over time rather than remaining fixed at a single rate across the retiree's career. This idealized, uninterrupted compounding

assumption may therefore overstate the precision of the projected fund accumulation relative to what a typical lecturer would actually experience. Future work should incorporate stochastic or time-varying interest rate models, together with empirically observed remittance patterns, to better reflect the variability of PFA investment performance and contribution flows over a career.

Second, the salary progression model assumes an uninterrupted, three-year promotion cycle from Assistant Lecturer through to Professor, with no allowance for delayed promotions, missed promotion cycles, or career breaks that are common in practice due to funding constraints, administrative bottlenecks, or individual circumstances. The model further assumes that each promotion-linked salary increase takes effect immediately on October 1 of the relevant year. Deviations from this idealized promotion schedule whether through delay or acceleration would alter the salary trajectory and, consequently, the accumulated contribution base and final retirement fund, in ways not captured by the present analysis. Future research should relax the fixed promotion-cycle assumption and instead model career progression probabilistically, incorporating empirical data on promotion delays and career interruptions across the Nigerian university system, to generate a more realistic distribution of possible salary trajectories.

Third, and perhaps most significantly, the interest rates applied throughout this study are nominal rates and do not account for inflation (Ikpe et al., 2021; Osamwonyi & Ikponmwosa, 2018). Given Nigeria's history of persistent and, at times, high inflation, the real (inflation-adjusted) value of both accumulated pension funds and periodic retirement payouts may be substantially lower than the nominal figures reported here suggest. This omission means the study's projections should be interpreted as indicative of nominal fund growth and income adequacy rather than of real purchasing power at retirement, and the reported replacement rates in particular should be treated with caution as a measure of actual living-standard maintenance. Future work should explicitly deflate nominal fund values and payouts using projected or historical Nigerian inflation rates to obtain real-terms estimates of retirement income adequacy, and should examine the sensitivity of the results to alternative inflation scenarios.

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Appendix 1: Consolidated Universities Academic Salary Structure (CONUASS) Per Annum — Effective Date: 29th July 2024

CONUASS	1	2	3	4	5	6	7	8	9	10	11	12	13
1	2,327,557	2,381,030	2,434,503	2,487,976	2,541,449	2,594,922	—	—	—	—	—	—	—
2	2,599,713	2,662,647	2,725,585	2,788,522	2,851,458	2,914,395	2,977,331	3,040,268	—	—	—	—	—
3	2,887,448	2,955,832	3,024,217	3,092,601	3,160,986	3,229,370	3,297,754	3,366,138	—	—	—	—	—
4	3,511,653	3,621,130	3,730,607	3,840,086	3,949,564	4,059,041	4,168,520	4,277,998	4,387,475	—	—	—	—
5	4,765,058	4,922,061	5,079,063	5,236,065	5,393,068	5,550,070	5,707,072	5,864,074	6,021,077	6,178,079	6,335,081	6,492,084	6,649,086
6	5,699,772	5,889,545	6,079,318	6,269,091	6,458,863	6,648,636	6,838,409	7,028,182	7,217,955	7,407,729	—	—	—
7	7,328,847	7,567,495	7,806,145	8,044,794	8,283,441	8,522,091	8,760,742	8,999,393	9,238,040	9,476,689	—	—	—