Ingenium Journal of Science, Technology and Business (IJSTB)
Vol. 1 No. 1. Desember 2026, pp. 01-24 DOI. 10.68374/ijstb.v1i1.21

Research Article

SURVIVAL PROBABILITY AND LIFE EXPECTANCY OF INDONESIANS UNDER TMPI-23 COMPARED WITH TMI IV AND TMJ-22

Muhammad Hasrul Hasan[1], Ahmad Juliana[2], Rias Wita Suryani[3], Julian Ransangan[4]
[1] Chairman Indonesian Broadcasting Commission, Indonesia
[2] Faculty of Economics, Borneo Tarakan University, Indonesia
[3] Faculty of Design, Indonesian Institute of the Arts, Padang Panjang, Indonesia
[4] Borneo Marine Research Institute, Universiti Malaysia Sabah, Malaysia

Corresponding Author:

Muhammad Hasrul Hasan,
Indonesian Broadcasting Commission, Indonesia.
Jl. Ir. H. Juanda No. 36, RT.7/RW.2, Kebon Kelapa, Kecamatan Gambir, Kota Jakarta Pusat, 10120.
Email: hasrulnews@gmail.com

Article Info

Received: September 1, 2026
Revised: September 29, 2026
Accepted: Otober 6, 2026
Online Version: Desember 1, 2026

Abstract

This study analyses the survival probability and life expectancy of the Indonesian population using the 2023 Indonesian Population Mortality Table (TMPI-23), compiled from 254.8 million National Health Insurance participants, and compares the results with the Indonesian Mortality Table IV (TMI IV) and the 2022 Social Security Mortality Table (TMJ-22). Using a quantitative descriptive actuarial design, the complete male and female tables were reconstructed and validated, multi-year survival probabilities and curtate life expectancies were derived, and the Gompertz and Makeham laws were fitted to adult ages 30–90. Life expectancy at birth is 73.74 years for males and 78.37 years for females, the probability of surviving from birth to age 65 is 0.739 and 0.791, and the median age at death is 77.2 and 83.3 years, respectively. The Gompertz law explains about 99 percent of the variation in log adult mortality, with mortality doubling every 9.4 years for males and 10.3 years for females, whereas the Makeham constant converges to zero. Life expectancy at birth under TMPI-23 is 2.3–4.3 years lower than under TMI IV and TMJ-22, reflecting underwriting and healthy-worker selection. The novelty lies in using the population-wide table as the actuarial benchmark; insured-lives tables therefore understate mortality for unselected populations.

Keywords: Gompertz Law, Life Expectancy, Mortality Table, Survival Probability, TMPI-23

© 2026 by the author(s)
This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution-ShareAlike 4.0 International (CC BY SA) license (https://creativecommons.org/licenses/by-sa/4.0/).

Journal Homepage https://journal.aisholarborneo.org/index.php/ijstb
How to cite: Hasan, H, Juliana, A, Suryani, W, R. (2026). Survival Probability and Life Expectancy of Indonesians Under TMPI-23 Compared with TMI IV and TMJ-22. Ingenium Journal of Science, Technology and Business, 1(1), 01–24. https://doi.org/ 10.68374/jjjs.v1i1.21
Published by: PT. Andalas Borneo Justice

INTRODUCTION

The length of human life is uncertain at the level of the individual, yet remarkably regular at the level of a population. This regularity is the foundation on which actuarial science measures, prices, and manages risks that depend on whether a person survives or dies. Every life insurance premium, annuity factor, pension liability, and social security projection rests, explicitly or implicitly, on a statement about the probability that a person aged x will survive to a given age and on the expected number of years that person still has to live (Bowers et al., 1997; Dickson et al., 2020). In the classical formulation of life contingencies, these quantities are derived from a mortality table, also called a life table, which records for each age the probability of dying within one year and, by extension, the full survival distribution of a hypothetical cohort (Gerber, 1997; Promislow, 2015). Because the mortality table is the single most important demographic assumption in actuarial valuation, the choice of table directly determines the adequacy of premiums, the sufficiency of reserves, and the long-term sustainability of insurance and social protection programmes (Futami, 1993; Pitacco et al., 2009).

The mathematical description of human mortality has a long history. Gompertz (1825) observed that, over most of adult life, the force of mortality increases approximately exponentially with age, and Makeham (1860) extended this law by adding an age-independent component intended to capture causes of death unrelated to ageing. These parametric laws remain the reference point for graduating and extrapolating adult mortality. Later work proposed richer age patterns covering childhood, the accident hump, and senescence in a single curve (Heligman & Pollard, 1980), and the dynamic dimension of mortality was formalised in stochastic models of mortality improvement, most notably the Lee–Carter model (Lee & Carter, 1992) and its Poisson log-bilinear estimation (Brouhns et al., 2002), cohort-based extensions (Renshaw & Haberman, 2006), and two-factor models for older ages (Cairns et al., 2006). At the population level, the steady rise of record life expectancy documented by Oeppen and Vaupel (2002) has challenged earlier claims that human longevity is close to a fixed biological ceiling (Fries, 1980; Olshansky et al., 1990), while heterogeneity in individual frailty implies that the mortality observed in a population is shaped by selection as much as by ageing itself (Vaupel et al., 1979). These developments are synthesised in modern treatments of mortality modelling for actuarial applications (Macdonald et al., 2018) and in demographic texts on the measurement of population processes (Preston et al., 2001).

In Indonesia, the reference mortality tables for actuarial work have historically been produced by the life insurance industry. The Indonesian Mortality Table (Tabel Mortalita Indonesia, TMI) was first constructed in 1993 and subsequently revised in 1999 and 2011 (Asosiasi Asuransi Jiwa Indonesia et al., 2012). The fourth edition, TMI IV, was published in 2019 by the Indonesian Life Insurance Association in collaboration with the Society of Actuaries of Indonesia and other partners, based on insured-lives experience observed between 2013 and 2017 (Asosiasi Asuransi Jiwa Indonesia [AAJI], 2019). TMI IV has since become the standard basis for pricing and valuation in Indonesian life insurance and the most frequently used table in domestic actuarial research, including studies of net single premiums (Lestari et al., 2024), prospective and benefit reserves (Prionggo et al., 2022; Wardah et al., 2024; Sadli & Sari, 2025; Suyanto & Felita, 2026), and the sensitivity of reserves to the policy interest rate (Deswan et al., 2026). This work sits alongside broader methodological research on reserve methods with stochastic interest rates (Romantica et al., 2026) and on fractional premiums and fractional-age assumptions (Pratiwi et al., 2022; Fauziah & Amalia, 2024). Researchers have also fitted parametric laws to TMI IV, constructing Gompertz and Makeham versions of the table (Prabowo, 2022a; Nurhaliza et al., 2025; Febry et al., 2026) and applying it to Islamic insurance contributions (Prabowo, 2022b).

The construction of any mortality table involves two technical steps that strongly influence its final shape: the treatment of limited or unreliable data at particular ages and the smoothing, or graduation, of crude rates. When the observed population at an age is small, crude rates are combined with a reference table through credibility weighting, and the resulting rates are then graduated so that they progress smoothly with age. Whittaker–Henderson graduation, which balances fidelity to the crude rates against smoothness, has been applied to Indonesian national data by Setiady and Kusnadi (2024) and was also used in constructing TMPI-23 (BPJS Kesehatan, 2023). Where only abridged data in five-year age groups are available, complete single-age tables can be obtained from model life tables (Coale et al., 1983) or by interpolation; Khaliludin et al. (2019) compared interpolation methods for Malaysian mortality, and Puspita et al. (2020) estimated an Indonesian male life table by smoothing survivorship probabilities with reference to the Coale–Demeny tables. Parametric laws offer a third route, replacing the tabulated rates by a small number of interpretable parameters (Gompertz, 1825; Makeham, 1860; Heligman & Pollard, 1980). Each route embodies assumptions about the true age pattern of mortality, and understanding these assumptions is essential when tables built in different ways are compared.

A structural limitation of TMI IV, however, is that it describes the mortality of insured lives. Commercial life insurance applicants pass through underwriting, and insured populations are typically wealthier, healthier, and more urban than the general population. Consequently, TMI IV is not designed to represent the mortality of Indonesians as a whole. Setiady and Kusnadi (2024), who graduated national mortality rates from World Health Organization data using the Whittaker–Henderson method, found that mortality among older Indonesians in the national data was substantially higher than among the insured lives of TMI IV, and attributed the difference to underwriting selection. A second source is the mortality table of the national employment social security agency. BPJS Ketenagakerjaan, in cooperation with the Faculty of Mathematics and Natural Sciences of Institut Teknologi Bandung, released the 2022 Social Security Mortality Table (TMJ-22), updating earlier tables issued in 2010 and 2017 (BPJS Ketenagakerjaan, 2023). Because workers join the programme without individual risk selection, TMJ-22 reflects the mortality of formally employed wage earners rather than that of underwritten policyholders, and it has begun to appear in product-design research (Suryamika & Novika, 2024). Nevertheless, neither TMI IV nor TMJ-22 covers children, the informal sector, or the full older population.

This gap was addressed by the publication of the 2023 Indonesian Population Mortality Table (Tabel Mortalitas Penduduk Indonesia 2023, TMPI-23) by BPJS Kesehatan, the administrator of the National Health Insurance (Jaminan Kesehatan Nasional, JKN) programme (BPJS Kesehatan, 2023). The JKN programme, established under the National Social Security System Law (Republik Indonesia, 2004), covered more than nine in ten Indonesians by the end of 2022. TMPI-23 was constructed from an experience study of 254.8 million JKN participants observed from 2018 to 2022, which corresponds to a penetration of 92.42 percent of the projected 2022 population, and it covers ages 0 to 111 separately for males and females (BPJS Kesehatan, 2023). In terms of coverage, it is therefore the closest available approximation to a complete actuarial life table of the Indonesian population. Official estimates of life expectancy are also published by Statistics Indonesia (Badan Pusat Statistik, 2024), but these are summary indicators rather than full age-specific tables suitable for actuarial calculation.

The need for an accurate population-wide description of survival is reinforced by Indonesia's demographic transition. Falling fertility and mortality are shifting the age structure towards older ages, so that the number of people who survive into retirement and the length of time they remain alive are growing faster than the working-age population. In such a setting, the actuarial quantities of the life table acquire a policy dimension. The probability of surviving through the working ages determines how many contributors will qualify for old-age benefits, the expectation of life at retirement determines how long pensions must be paid, and the shape

of mortality at very old ages determines the cost of long-term care and health insurance for the oldest old (Pitacco et al., 2009; Macdonald et al., 2018). Statistics Indonesia publishes life expectancy estimates by province and sex that are monitored as indicators of human development (Badan Pusat Statistik, 2024), and international experience shows that gains in survival at older ages tend to continue for decades once a population has passed through the epidemiological transition (Oeppen & Vaupel, 2002). Errors in the underlying mortality table therefore translate into systematic mispricing of social and commercial protection precisely when the stakes are increasing.

From a theoretical standpoint, the life table can be viewed in two equivalent ways. In the probabilistic view, the future lifetime of a person aged x is a random variable whose distribution is completely characterised by the survival function, from which the probabilities of survival and death over any interval, the force of mortality, and the moments of the future lifetime are derived (Bowers et al., 1997; Gerber, 1997). In the deterministic or cohort view, the table describes how a hypothetical group of newborns is depleted by death year by year, so that the number of survivors and deaths at each age provide an intuitive representation of the same distribution (Futami, 1993; Preston et al., 2001). Both views lead to identical numerical results, and both are used here: the cohort functions support the demographic interpretation of the results, while the probabilistic functions provide the link to actuarial present values. A further distinction is made between the curtate future lifetime, which counts completed years, and the complete future lifetime, which includes the fraction of the year lived in the year of death; the corresponding expectations differ by approximately half a year under the usual fractional-age assumptions (Dickson et al., 2020; Promislow, 2015).

The availability of three tables built on very different populations, namely insured lives (TMI IV), formal-sector workers (TMJ-22), and the near-universal JKN population (TMPI-23), raises questions that matter both for actuarial practice and for social policy. What is the probability that an Indonesian survives from birth, from the start of working life, or from retirement age to specified older ages? How many years of life remain at each age, and how large is the gap between males and females? How well do the classical laws of Gompertz and Makeham describe adult mortality in the national table? And how do survival and life expectancy implied by the population table compare with those implied by the insured-lives and social-security tables that dominate current actuarial practice? Existing Indonesian studies have overwhelmingly used TMI IV as an input to premium and reserve calculations; very few have analysed survival and life expectancy themselves as the object of study, and almost none have exploited the population-wide TMPI-23 or set it against TMI IV and TMJ-22.

The objectives of this study are therefore fourfold. First, it reconstructs the complete life table of TMPI-23 for males and females and verifies it against the published values. Second, it derives a comprehensive set of survival and life expectancy indicators, including multi-year survival probabilities, curtate and complete life expectancy, the median and modal ages at death, and the sex gap at every age. Third, it fits the Gompertz and Makeham laws to adult mortality in TMPI-23 and assesses their adequacy. Fourth, it compares the life expectancy at birth implied by TMPI-23 with that of TMI IV, TMJ-22, and other national and international estimates, and interprets the differences in terms of population composition, selection, and data quality. The novelty of the study lies in treating the national population table, rather than the insured-lives table, as the primary actuarial description of Indonesian longevity and in quantifying how far the tables used in practice depart from it. The findings are intended to inform actuaries in life insurance, pension, and social security institutions regulated under the Insurance Law (Republik Indonesia, 2014) and the social security framework, as well as researchers and policymakers concerned with population ageing.

RESEARCH METHOD

This study employs a quantitative descriptive design based on secondary data and the deterministic life-table methodology of actuarial mathematics. The analysis does not estimate mortality from raw exposure and death counts; instead, it takes the graduated mortality rates of published tables as given and derives from them the survival and life expectancy functions that characterise each population. This approach follows the standard treatment of the life table as a complete description of a survival distribution (Bowers et al., 1997; Dickson et al., 2020) and is consistent with the methods used in Indonesian actuarial textbooks (Futami, 1993).

Research Design

The research is designed as a descriptive and comparative actuarial analysis in three stages. In the first stage, the complete TMPI-23 life tables for males and females are reconstructed from the published one-year probabilities of death, and the reconstructed curtate life expectancies are checked against those printed in the source to confirm the accuracy of data extraction. In the second stage, survival and life expectancy indicators are derived for both sexes, and the age pattern of adult mortality is modelled with the Gompertz and Makeham laws. In the third stage, the resulting life expectancies at birth are compared with those of TMI IV, TMJ-22, and other published estimates, and the differences are interpreted in light of the populations and construction methods underlying each table.

Time and Place of Research

The study was conducted as a desk-based analysis in 2026. The empirical setting is Indonesia as a whole. The TMPI-23 data refer to the experience of JKN participants during the observation period 2018–2022 (BPJS Kesehatan, 2023), TMI IV refers to insured-lives experience in 2013–2017 (AAJI, 2019), and TMJ-22 refers to the experience of wage-earning participants of the employment social security programme (BPJS Ketenagakerjaan, 2023).

Research Target/Subject

The object of the study is the mortality experience of the Indonesian population as summarised in the three mortality tables. No sampling was performed, because the analysis uses complete published tables rather than individual records. The primary data are the TMPI-23 tables for males and females at single ages 0 to 111. TMPI-23 was built from 254.8 million JKN participants, with deaths obtained partly from population registration data; crude rates were combined with TMI IV through partial credibility and were then smoothed with the Whittaker–Henderson graduation method (BPJS Kesehatan, 2023). Over the five-year observation period, the ratio of actual to expected deaths under the final table was 100.62 percent for both sexes, indicating that the table reproduces the observed number of deaths closely. For comparison, TMI IV was derived from 22,695,777 insured-lives records with 136,094 death claims, and TMJ-22 was derived from 31,753,304 exposures with 176,606 deaths among wage-earning participants (BPJS Kesehatan, 2023).

Table 1 summarises the main characteristics of the three tables. The tables differ not only in the size of their observed populations but also in the mechanism by which individuals enter observation. Entry into TMI IV is conditioned on purchasing life insurance and passing underwriting, entry into TMJ-22 is conditioned on formal employment, and entry into TMPI-23 is conditioned only on JKN membership, which is mandatory for all residents. These differences in entry mechanisms are central to the interpretation of the comparative results, because selection at entry is one of the most powerful determinants of observed mortality (Vaupel et al., 1979; Macdonald et al., 2018).

Table 1. Characteristics of the Three Mortality Tables Compared in This Study

Characteristic	TMI IV	TMJ-22	TMPI-23
Publisher	AAJI with PAI and partners	BPJS Ketenagakerjaan with FMIPA ITB	BPJS Kesehatan
Population observed	Insured lives (underwritten)	Wage-earning social security participants	JKN participants (near-universal)
Observation period	2013–2017	Experience to 2022	2018–2022
Exposure	22,695,777 records	31,753,304 exposures	254.8 million participants
Deaths	136,094 claims	176,606 deaths	Administrative and registration data
Life expectancy at birth (M/F)	78 / 82	76 / 82	73.74 / 78.37

The adequacy of TMPI-23 as a description of observed mortality was assessed in the source publication through the ratio of actual to expected deaths for each year of the observation period, reproduced in Table 2. The ratio fluctuates between 85.59 and 109.21 percent across years and sexes, and the five-year aggregate is 100.62 percent for both males and females. The ratios below 100 percent in 2020 for males and in 2020–2021 for females are attributed in the source to the COVID-19 pandemic, which may have disrupted the reporting of participant deaths, whereas ratios above 100 percent indicate that actual deaths exceeded those expected under the table (BPJS Kesehatan, 2023). Because TMPI-23 does not separate pandemic-related deaths, it should be read as a period table reflecting the average conditions of 2018–2022.

Table 2. Actual-to-Expected Death Ratios of TMPI-23 by Year and Sex (%)

Period	Male	Female
2018	104.88	101.78
2019	106.52	108.11
2020	89.67	85.59
2021	101.04	97.75
2022	102.02	109.21
2018–2022	100.62	100.62

Research Procedure

The procedure consisted of five sequential steps. (1) The appendix tables of TMPI-23 for males and females were extracted, containing for each age the central exposure, the number of deaths, the graduated probability of death, the probability of survival, and the curtate life expectancy. (2) A radix of $l_0 = 100{,}000$ was applied, and the life-table functions were rebuilt recursively from the graduated probabilities of death. (3) The reconstructed curtate life expectancies were compared with the published values at every age as a validity check. (4) Survival probabilities, life expectancies, and summary indicators of the age-at-death distribution were computed. (5) The Gompertz and Makeham laws were fitted to adult mortality, and the life expectancies at birth from TMPI-23 were set against those reported for TMI IV, TMJ-22, and other sources.

Instruments, and Data Collection Techniques

The data were collected through documentation of official publications. The principal document is the TMPI-23 volume published by BPJS Kesehatan (2023), whose appendices list

the complete male and female tables and whose comparative chapter reports the life expectancy at birth implied by TMI IV and TMJ-22 together with estimates from Statistics Indonesia, the United Nations, and the Global Burden of Disease study. The TMI IV and TMJ-22 publications (AAJI, 2019; BPJS Ketenagakerjaan, 2023) and the life expectancy statistics of Statistics Indonesia (Badan Pusat Statistik, 2024) served as supporting documents. Because the age-specific probabilities of TMI IV and TMJ-22 were not available to the authors in tabular form, the comparison across the three tables is made through the life expectancy at birth reported in the TMPI-23 volume and through the published descriptions of where the age-specific curves cross. All calculations were carried out in Python and cross-checked in a spreadsheet.

Data Analysis Technique

The analysis rests on the standard functions of the life table (Bowers et al., 1997; Gerber, 1997; Dickson et al., 2020). Let l_x denote the expected number of survivors to exact age x out of the radix l_0, let d_x denote the expected number of deaths between ages x and $x + 1$, and let q_x and p_x denote the one-year probabilities of death and survival. These functions are linked by the relations

$$q_x = d_x / l_x, \quad p_x = 1 - q_x \tag{1}$$

$$l_{x+1} = l_x \cdot p_x, \quad d_x = l_x - l_{x+1} \tag{2}$$

Survival over several years is obtained as the product of successive one-year survival probabilities. The probability that a person aged x survives t further years, the probability of dying within those years, and the probability of dying in the year following survival to age $x + t$ are

$${}_tp_x = l_{x+t} / l_x = p_x \cdot p_{x+1} \cdot \ldots \cdot p_{x+t-1} \tag{3}$$

$${}_tq_x = 1 - {}_tp_x, \quad {}_{t|}q_x = {}_tp_x \cdot q_{x+t} \tag{4}$$

The curtate expectation of life, which counts only completed years, and the complete expectation of life are

$$e_x = \Sigma_{k=1}^{\omega - x} {}_kp_x, \quad \mathring{e}_x \approx e_x + 0.5 \tag{5}$$

where $\omega = 111$ is the limiting age of the table and the approximation for the complete expectation follows from the assumption of a uniform distribution of deaths within each year of age (Bowers et al., 1997). The curtate measure is the one published in TMPI-23 and is used throughout unless stated otherwise. The distribution of the age at death was summarised by the median age at death, defined as the age at which l_x falls to half of the radix and obtained by linear interpolation, and by the modal age at death above childhood, defined as the age with the largest d_x for $x \geq 10$. The survival function itself is the life-table analogue of the product-limit estimator of Kaplan and Meier (1958), with the difference that the probabilities here are graduated rates rather than raw empirical proportions. Two indicators commonly used in demographic and public health analysis were also computed: the probability of dying before age five, ${}_5q_0$, and the probability that a person aged 15 dies before age 60, ${}_{45}q_{15}$ (Preston et al., 2001).

To examine the age pattern of adult mortality, the force of mortality at mid-year was approximated from the one-year probability of death, and two parametric laws were fitted over ages 30 to 90:

$$\hat{\mu}_{x+0.5} \approx -\ln(1 - q_x) \tag{6}$$

$$\text{Gompertz: } \mu_x = B\, c^x, \quad \text{Makeham: } \mu_x = A + B\, c^x \tag{7}$$

The Gompertz parameters were estimated by ordinary least squares on the linearised form $\ln \mu_x = \ln B + x \ln c$, and the Makeham parameters by nonlinear least squares on the logarithmic scale, which gives equal relative weight to all ages and is the approach adopted in comparable Indonesian studies (Prabowo, 2022a; Nurhaliza et al., 2025). Goodness of fit was assessed with the coefficient of determination on the log scale and the mean absolute

percentage error of the fitted force of mortality, overall and by age band. The Gompertz slope was translated into the mortality rate doubling time,

$$\text{MRDT} = \ln 2 / \ln c \quad (8)$$

which is the number of years over which the force of mortality doubles. Finally, to illustrate the actuarial consequences of the survival pattern, the actuarial present value of a whole-life annuity-due of one unit per year and the net single premium of a whole-life insurance of one unit payable at the end of the year of death were computed at an illustrative interest rate of $i = 6$ percent, with $v = 1/(1 + i)$:

$$\ddot{a}_x = \Sigma_{k=0}^{\omega-x} v^k \cdot {}_kp_x, \quad A_x = \Sigma_{k=0}^{\omega-x} v^{k+1} \cdot {}_kp_x \cdot q_{x+k} \quad (9)$$

These are the same building blocks used in the premium and reserve studies that rely on TMI IV (Lestari et al., 2024; Sadli & Sari, 2025), so the values provide a direct bridge between the demographic findings and actuarial pricing.

Several assumptions underlie the analysis. First, TMPI-23 is treated as a period table: its probabilities describe the mortality of 2018–2022 and are applied to a hypothetical cohort as if those conditions persisted throughout life, so that the life expectancies are period measures rather than forecasts of the actual lifetimes of people born today (Preston et al., 2001). Second, the table closes at age 111 with a probability of death equal to one, following the source publication. Third, deaths are assumed to be uniformly distributed within each year of age when complete expectations and mid-year forces of mortality are computed (Bowers et al., 1997). Fourth, the interest rates used in the actuarial illustrations are not intended to represent any particular market or regulatory basis; they serve only to show how the survival pattern translates into present values. Finally, no adjustment is made for future mortality improvement, consistent with the static nature of all three tables compared.

RESULTS AND DISCUSSION

Validation of the Reconstructed Life Table

The extraction of the male and female TMPI-23 tables yielded 112 ages each (0 to 111). In every row, the published probabilities of death and survival summed to one. When the life tables were rebuilt from the graduated probabilities of death and the curtate life expectancy was recomputed at every age, the largest absolute difference from the published values was 0.005 years for both sexes, which is attributable solely to rounding in the printed table. The reconstructed life expectancy at birth is 73.74 years for males and 78.37 years for females, identical to the values reported by BPJS Kesehatan (2023). The reconstruction is therefore a faithful reproduction of TMPI-23 and provides a sound basis for the indicators derived below.

Age Pattern of the Probability of Death

Table 3 presents an abridged version of the reconstructed life table, and Figure 1 displays the probability of death at every age on a logarithmic scale. The age profile follows the familiar shape of human mortality. The probability of death in the first year of life is 0.00979 for males and 0.00788 for females, after which it falls sharply to a minimum around the end of the first decade of life, reached at age 11 for males (0.000504) and at age 10 for females (0.000432). Mortality then rises slowly through adolescence and young adulthood, with only a faint trace of the accident hump that is prominent in many high-income populations (Heligman & Pollard, 1980), and accelerates from the mid-thirties onwards. The male probability of death reaches 1 percent at age 54 and 5 percent at age 81, while the corresponding female thresholds are reached at ages 57 and 86. A probability of death of 10 percent is reached at age 89 for males and 93 for females.

Table 3. Abridged Life Table of TMPI-23 by Sex (Radix l_0 = 100,000)

Age (*x*)	q_x Male	q_x Female	l_x Male	l_x Female	e_x Male	e_x Female
0	0.00979	0.00788	100,000	100,000	73.74	78.37
1	0.00253	0.00210	99,021	99,212	73.47	77.99
5	0.00058	0.00047	98,536	98,809	69.82	74.30
10	0.00051	0.00043	98,262	98,582	65.01	69.47
15	0.00062	0.00053	98,002	98,357	60.18	64.63
20	0.00082	0.00072	97,660	98,064	55.38	59.81
25	0.00108	0.00097	97,213	97,664	50.63	55.05
30	0.00139	0.00123	96,631	97,141	45.92	50.33
35	0.00185	0.00158	95,883	96,484	41.26	45.66
40	0.00268	0.00223	94,861	95,615	36.68	41.06
45	0.00418	0.00346	93,348	94,348	32.24	36.58
50	0.00693	0.00560	90,976	92,373	28.03	32.32
55	0.01140	0.00871	87,106	89,272	24.17	28.36
60	0.01660	0.01231	81,440	84,854	20.71	24.73
65	0.02327	0.01623	73,899	79,116	17.61	21.37
70	0.03030	0.02012	64,795	72,350	14.79	18.18
75	0.03871	0.02527	54,581	64,698	12.18	15.09
80	0.04811	0.03251	44,028	56,191	9.62	12.06
85	0.06953	0.04640	33,123	46,418	7.12	9.16
90	0.11059	0.07182	21,352	34,971	4.93	6.49
95	0.18317	0.12740	10,226	21,704	3.19	4.20
100	0.29112	0.22557	2,872	8,887	1.98	2.53
105	0.42507	0.36994	348	1,712	1.18	1.40
110	0.56627	0.55968	13	90	0.43	0.44

The male probability of death exceeds the female probability at every age below the terminal age. The ratio of male to female mortality is 1.24 at birth, declines to about 1.11 to 1.14 in the twenties and early thirties, and then rises steadily through middle age to a peak of 1.54 at age 89, before converging towards one at the extreme ages where the graduated rates of both sexes approach the closing value of the table. This excess male mortality during working and early retirement ages is consistent with the higher premiums for men reported in Indonesian pricing studies based on TMJ-22 (Suryamika & Novika, 2024) and on TMI IV (Lestari et al., 2024), and it reflects well-documented differences in behavioural and occupational risk between the sexes.

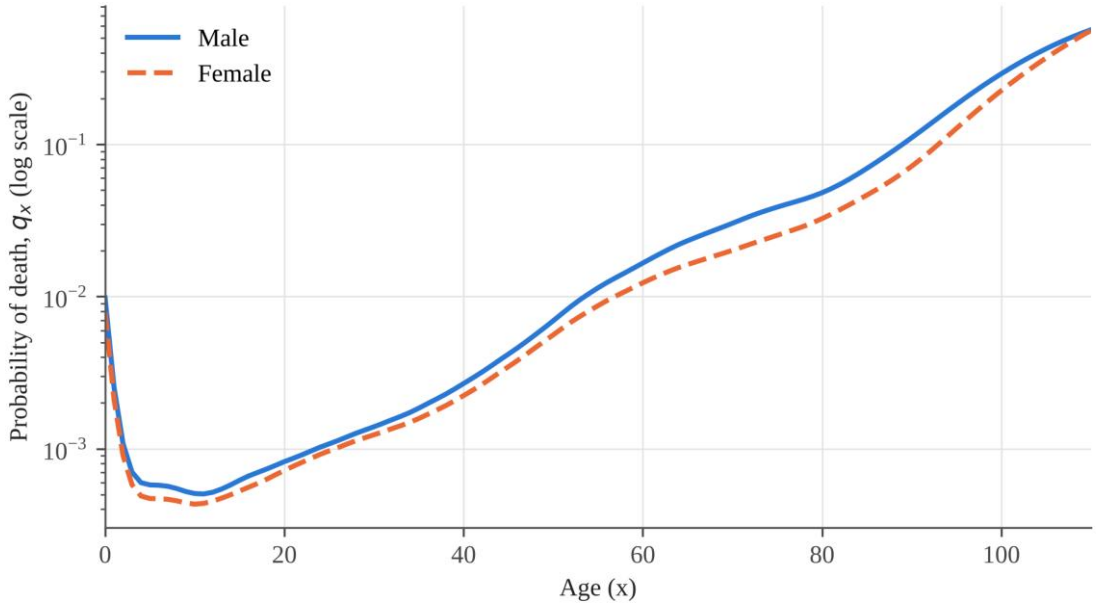


Figure 1. Probability of Death q_x by Age and Sex, TMPI-23 (Logarithmic Scale)

A distinctive feature of TMPI-23 is the shape of mortality at very old ages. As Figure 1 shows, the slope of the logarithmic mortality curve flattens noticeably between about ages 60 and 80, where the annual rate of increase falls to roughly 4 to 5 percent, and then steepens again in the eighties, and the probabilities of death above age 100 remain well below the levels found in many national tables. The source publication notes that TMPI-23 mortality above about age 80 is lower than that of TMI IV and, for males, also lower than that of TMJ-22, whereas at younger ages TMPI-23 mortality is higher than in both comparison tables (BPJS Kesehatan, 2023). This pattern is examined further in the discussion of data quality below.

Survivorship and the Distribution of Deaths

Figure 2 shows the number of survivors l_x out of 100,000 births. The survival curves remain almost flat until about age 40, with 94,861 males and 95,615 females still alive at that age, and then decline at an increasing rate. By age 65, 73,899 males and 79,116 females survive; by age 80, the numbers fall to 44,028 and 56,191; and only 2,872 males and 8,887 females reach age 100. The median age at death, at which half of a birth cohort has died, is 77.2 years for males and 83.3 years for females. Both medians lie above the corresponding life expectancies at birth, a typical result for populations in which deaths are concentrated at older ages but a minority of early deaths pulls the mean below the median.

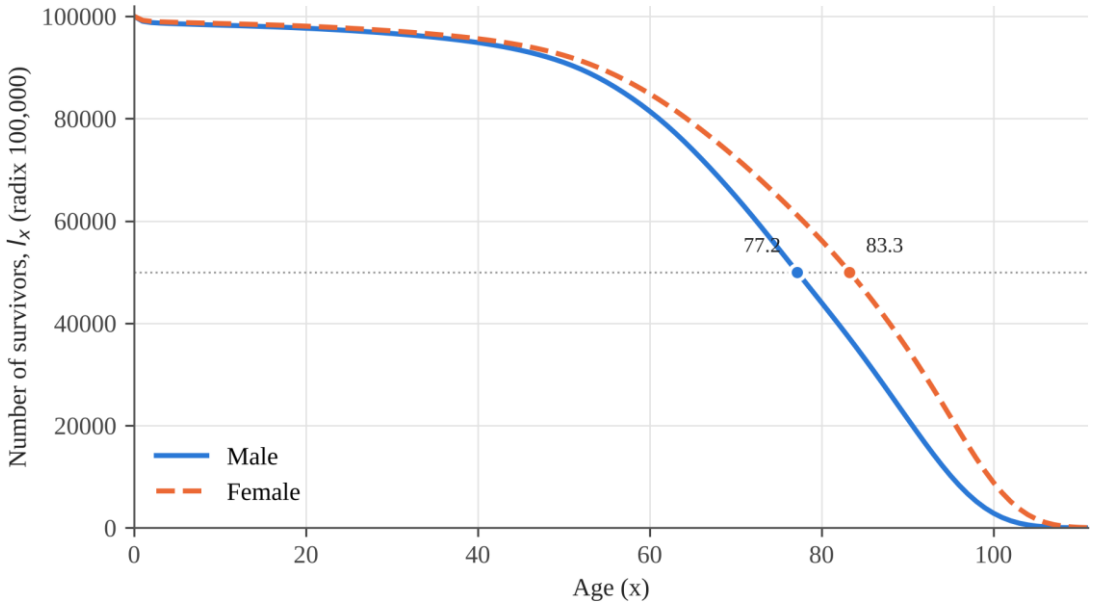


Figure 2. Number of Survivors l_x out of 100,000 Births by Sex, TMPI-23 (Markers Indicate the Median Age at Death)

The distribution of life-table deaths in Figure 3 makes the concentration of mortality at older ages explicit. Apart from the deaths in the first year of life (979 male and 788 female deaths per 100,000 births), very few deaths occur before age 40. Deaths rise steeply from the late forties onwards. The male distribution displays a shoulder in the seventies and a mode at age 88, while the female distribution is shifted to the right with a mode at age 94. In demographic terms, the modal age at death is often interpreted as the most typical length of life in a population (Preston et al., 2001). The distance between the medians and the modes indicates that a substantial share of deaths still occurs in late middle age, particularly among men, which is the age range in which non-communicable diseases dominate the burden of mortality in Indonesia.

Table 4 condenses the distribution of life-table deaths into broad age groups, expressed as the percentage of a birth cohort dying in each group. Fewer than 2 percent of births die before age 15 for either sex, and fewer than 5 percent die between ages 15 and 44. The decisive differences between the sexes appear later. Almost one in five males (19.45 percent) but only about one in seven females (15.23 percent) die between ages 45 and 64, and a further 29.87 percent of males compared with 22.92 percent of females die between ages 65 and 79. In consequence, only 44.03 percent of males survive to die at age 80 or older, compared with 56.19 percent of females. These proportions offer an intuitive summary of the survival function: in TMPI-23, death at an advanced age is the majority experience for women but still a minority experience for men.

The dispersion of the age at death can be summarised by the quartiles of the life-table death distribution. One quarter of a male birth cohort has died by age 64.3 and three quarters by age 88.5, giving an interquartile range of 24.1 years; for females, the corresponding quartiles are 68.1 and 93.8 years, with an interquartile range of 25.7 years. The female distribution is therefore shifted to older ages by about four to five years at both quartiles, but it is not more compressed than the male distribution. This observation is relevant to the long-standing debate on whether improvements in survival lead to a rectangularisation of the survival curve and a compression of deaths around a typical age (Fries, 1980) or rather to a shift of the entire distribution towards older ages (Oeppen & Vaupel, 2002). In TMPI-23, the comparison between the sexes resembles a shift more than a compression, although a single period table cannot establish a trend over time.

Table 4. Distribution of Life-Table Deaths by Age Group (% of a Birth Cohort), TMPI-23

Age group (years)	Male	Female
Under 1	0.98	0.79
1–4	0.48	0.40
5–14	0.53	0.45
15–44	4.65	4.01
45–64	19.45	15.23
65–79	29.87	22.92
80 and over	44.03	56.19
Total	100.00	100.00

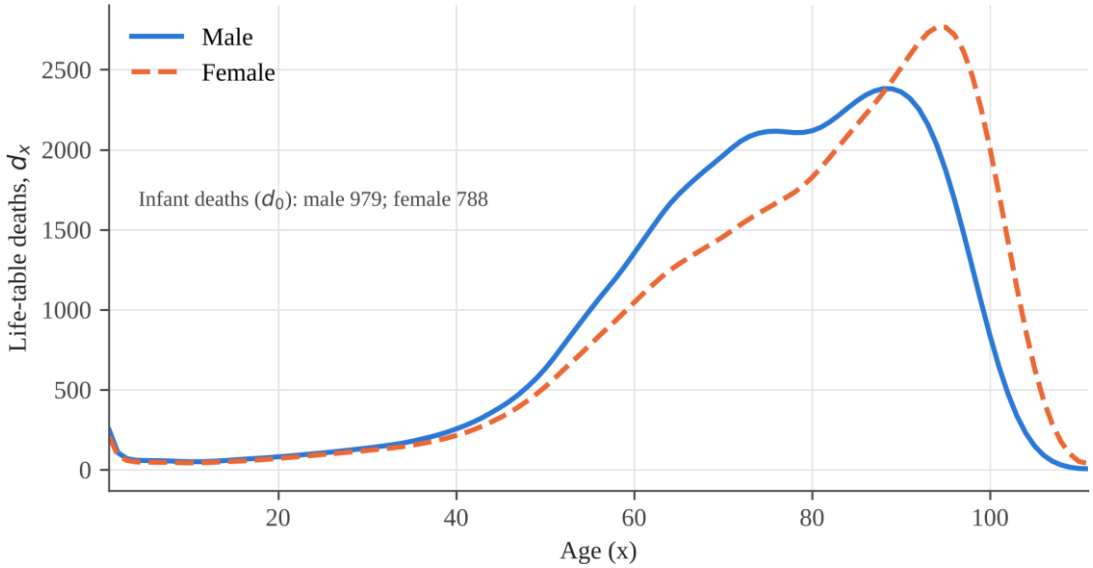


Figure 3. Distribution of Life-Table Deaths d_x by Age and Sex, TMPI-23 (Ages 1–111)

Multi-Year Survival Probabilities

Table 5 summarises survival probabilities over intervals that are directly relevant to insurance, pension, and social security programmes. The probability of dying before age five is 1.46 percent for males and 1.19 percent for females. The probability that a newborn survives to age 60 is 0.814 for males and 0.849 for females, and the probability of survival to age 65 is 0.739 and 0.791, respectively. Survival to age 80 is markedly lower and markedly more unequal between the sexes: only 44.0 percent of males but 56.2 percent of females are expected to reach that age.

Table 5. Selected Survival Probabilities and Age-at-Death Indicators, TMPI-23

Indicator	Notation	Male	Female
Probability of dying before age 5	${}_5q_0$	0.0146	0.0119
Survival from birth to age 60	${}_{60}p_0$	0.8144	0.8485
Survival from birth to age 65	${}_{65}p_0$	0.7390	0.7912
Survival from birth to age 80	${}_{80}p_0$	0.4403	0.5619
Survival from birth to age 90	${}_{90}p_0$	0.2135	0.3497
Survival from birth to age 100	${}_{100}p_0$	0.0287	0.0889
Survival from age 20 to age 65	${}_{45}p_{20}$	0.7567	0.8068
Survival from age 20 to age 80	${}_{60}p_{20}$	0.4508	0.5730
Probability of dying between 15 and 60	${}_{45}q_{15}$	0.1690	0.1373
Survival from age 60 to age 80	${}_{20}p_{60}$	0.5406	0.6622
Survival from age 65 to age 85	${}_{20}p_{65}$	0.4482	0.5867
Median age at death (years)	–	77.2	83.3
Modal age at death, $x \geq 10$ (years)	–	88	94

From the perspective of working life, the probability that a person aged 20 survives to the conventional retirement age of 65 is 0.757 for males and 0.807 for females. Put differently, roughly one in four men and one in five women who enter the labour market at age 20 are expected to die before reaching 65. The complementary indicator ${}_{45}q_{15}$, the probability that a 15-year-old dies before age 60, is 16.9 percent for males and 13.7 percent for females. These figures are of direct relevance to the design of employment-related programmes such as old-age, death, and pension benefits, for which the probability of survival through the contribution period determines the balance between death and survival benefits (BPJS Ketenagakerjaan, 2023). For those who do reach retirement, the probability of surviving 20 further years is 0.541 for males aged 60 and 0.662 for females aged 60, and 0.448 and 0.587 for males and females aged 65. These retirement-age survival probabilities govern the duration of annuity and pension payments and therefore the exposure of providers to longevity risk (Pitacco et al., 2009).

Because the probability of reaching retirement depends on the age at which a person is observed, Table 6 reports the conditional probability of surviving to ages 60 and 65 for persons who are alive at ages 20, 30, 40, and 50. The probabilities increase with the starting age, since those who are older have already survived part of the risk, but the increase is modest until age 40 because mortality in early adulthood is low. A man aged 40 has a 0.779 probability of reaching 65 and a woman of the same age a 0.827 probability; at age 50, these probabilities rise to 0.812 and 0.857. Thus, even among people who have already reached middle age, almost one in five men and one in seven women are expected to die before age 65. For defined-benefit pension schemes and for the old-age and pension programmes of the employment social security system, these conditional probabilities determine the proportion of active members who will eventually draw retirement benefits and the proportion whose accumulated contributions will instead be paid as death benefits (BPJS Ketenagakerjaan, 2023; Republik Indonesia, 2004).

Table 6. Conditional Probability of Surviving to Ages 60 and 65 by Current Age, TMPI-23

Current age (x)	To 60, male	To 60, female	To 65, male	To 65, female
20	0.8339	0.8653	0.7567	0.8068
30	0.8428	0.8735	0.7648	0.8144
40	0.8585	0.8875	0.7790	0.8274
50	0.8952	0.9186	0.8123	0.8565

Life Expectancy by Age and the Sex Gap

Figure 4 presents the curtate life expectancy at each age together with the female–male difference. Life expectancy at birth is 73.74 years for males and 78.37 years for females, corresponding to complete life expectancies of 74.24 and 78.87 years. Because infant mortality is low, life expectancy changes little over the first year and then declines almost linearly with age. At age 20, males can expect to live 55.38 further years and females 59.81; at age 40, the corresponding values are 36.68 and 41.06; at age 60, 20.71 and 24.73; and at age 65, 17.61 and 21.37 years. At age 80, remaining life expectancy is 9.62 years for males and 12.06 years for females.

Expressed as complete expectations, which add the fraction of the final year lived under the uniform distribution of deaths, the corresponding values are 55.88 and 60.31 years at age 20, 21.21 and 25.23 years at age 60, 18.11 and 21.87 years at age 65, and 10.12 and 12.56 years at age 80. The complete measure is the one most often reported in demographic statistics, whereas the curtate measure is the natural input for discrete annual actuarial calculations (Bowers et al., 1997; Dickson et al., 2020). Comparisons between actuarial tables and official statistics should therefore take care to use the same definition, since the half-year difference is of the same order of magnitude as some of the differences between tables discussed below.



Figure 4. Curtate Life Expectancy e_x by Age and Sex (a) and the Female–Male Difference (b), TMPI-23

The sex gap in life expectancy is 4.63 years at birth. It remains almost constant, between 4.3 and 4.5 years, throughout childhood and early adulthood, because male and female mortality are both low at these ages and the gap is carried forward from the higher male mortality at later ages. From about age 50, the gap narrows progressively, to 4.02 years at age 60, 3.76 years at age 65, 2.44 years at age 80, and 0.55 years at age 100. The narrowing reflects the arithmetic of the life table: as fewer years remain, a given relative mortality differential translates into a smaller absolute difference in remaining lifetime. In actuarial terms, the persistence of a gap of nearly four years at age 65 implies that sex-neutral annuity and pension factors embed a considerable cross-subsidy from men to women, an issue that also arises when unisex tables are used for public pension schemes.

Parametric Modelling with the Gompertz and Makeham Laws

Figure 5 plots the logarithm of the estimated force of mortality between ages 30 and 90 together with the fitted Gompertz lines, and Table 7 reports the estimated parameters. The Gompertz law explains about 98.8 percent of the variation in log mortality for males and 98.7

percent for females, confirming that the near-exponential increase in adult mortality first described by Gompertz (1825) holds well for the Indonesian population. The estimated rate of increase c is 1.0763 for males and 1.0698 for females. These values imply that the force of mortality increases by 7.6 percent per year of age for males and 7.0 percent for females, so that mortality doubles every 9.4 years for males and every 10.3 years for females.

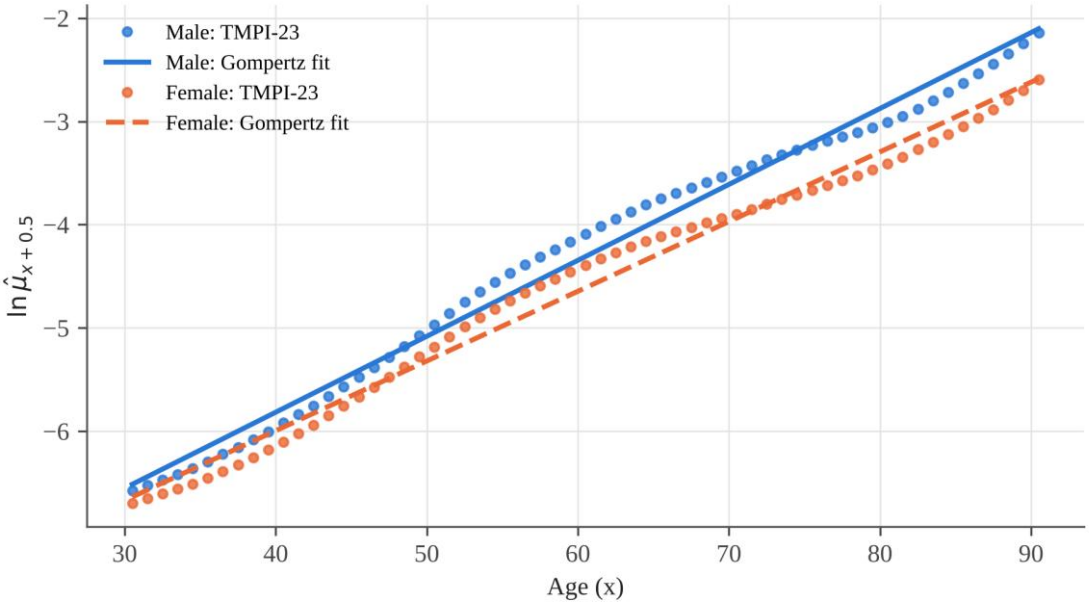


Figure 5. Logarithm of the Force of Mortality and Fitted Gompertz Law, Ages 30–90, TMPI-23

Table 7. Estimated Gompertz and Makeham Parameters for Ages 30–90, TMPI-23

Parameter or Statistic	**Male**	**Female**
Gompertz B	1.5733×10^{-4}	1.6731×10^{-4}
Gompertz c	1.0763	1.0698
Annual increase in μ_x (%)	7.63	6.98
Mortality rate doubling time (years)	9.43	10.27
R^2 (log scale)	0.9879	0.9873
MAPE of μ_x, ages 30–90 (%)	12.83	11.88
MAPE of μ_x, ages 30–49 (%)	10.70	10.68
MAPE of μ_x, ages 50–69 (%)	16.52	15.82
MAPE of μ_x, ages 70–90 (%)	11.34	9.26
Makeham A (converged value)	0	0

The fitted lines nevertheless reveal systematic departures. The observed points lie above the Gompertz line in the fifties and sixties and below it in the late seventies and eighties, so that the mean absolute percentage error of the fitted force of mortality is highest in the 50–69 age band (16.5 percent for males and 15.8 percent for females) and lower at ages 30–49 and 70–90. In other words, TMPI-23 mortality rises faster than exponentially in late middle age and more slowly than exponentially in early old age. Departures of this kind are the reason why Indonesian studies compare parametric laws with the tabulated rates before using them for valuation (Nurhaliza et al., 2025; Febry et al., 2026). For TMPI-23, the deceleration at older ages is pronounced and coincides with the flattening of the probability-of-death curve noted earlier.

The Makeham law did not improve upon the Gompertz law. When estimated on the logarithmic scale, the age-independent component A converged to its lower bound of zero for both sexes, so that the Makeham fit collapsed to the Gompertz fit with identical parameters and errors. This means that, in the adult age range of TMPI-23, there is no empirical support for a constant background hazard additional to the senescent component. The result contrasts with applications to the insured-lives table, where Makeham versions of TMI 2019 have been constructed and used as alternatives to the tabulated rates (Prabowo, 2022a), and it underlines the value of comparing both laws before adopting either, as Nurhaliza et al. (2025) did for TMI IV. The practical implication is that a two-parameter Gompertz law is sufficient for the central adult ages of TMPI-23, whereas the old-age pattern requires either a more flexible law, such as the Heligman–Pollard family (Heligman & Pollard, 1980), or a model that accounts for frailty and selection at advanced ages (Vaupel et al., 1979; Macdonald et al., 2018).

Comparison with TMI IV, TMJ-22, and Other Estimates

Table 8 and Figure 6 compare the life expectancy at birth implied by TMPI-23 with that implied by TMI IV and TMJ-22 and with estimates from Statistics Indonesia, the Global Burden of Disease study, and the United Nations, as compiled by BPJS Kesehatan (2023). The ranking is clear and consistent with the populations that underlie each table. TMI IV, based on underwritten insured lives, yields the highest life expectancy for males (78 years) and, jointly with TMJ-22, for females (82 years). TMJ-22, based on wage-earning workers, yields 76 years for males and 82 years for females. TMPI-23 yields 73.74 and 78.37 years. The estimates of Statistics Indonesia (69.93 and 73.83 years), the Global Burden of Disease study (69.4 and 73.5 years), and the United Nations (65.53 and 69.74 years) are lower still.

Table 8. Life Expectancy at Birth by Mortality Table or Source and Sex (Years)

Table or source	Male	Female	TMPI-23 minus source, male	TMPI-23 minus source, female
TMPI-23 (2023), JKN participants	73.74	78.37	–	–
TMI IV (2019), insured lives	78	82	−4.26	−3.63
TMJ-22 (2023), wage-earning workers	76	82	−2.26	−3.63
Statistics Indonesia (2022)	69.93	73.83	+3.81	+4.54
Global Burden of Disease (2019)	69.4	73.5	+4.34	+4.87
United Nations (2021)	65.53	69.74	+8.21	+8.63

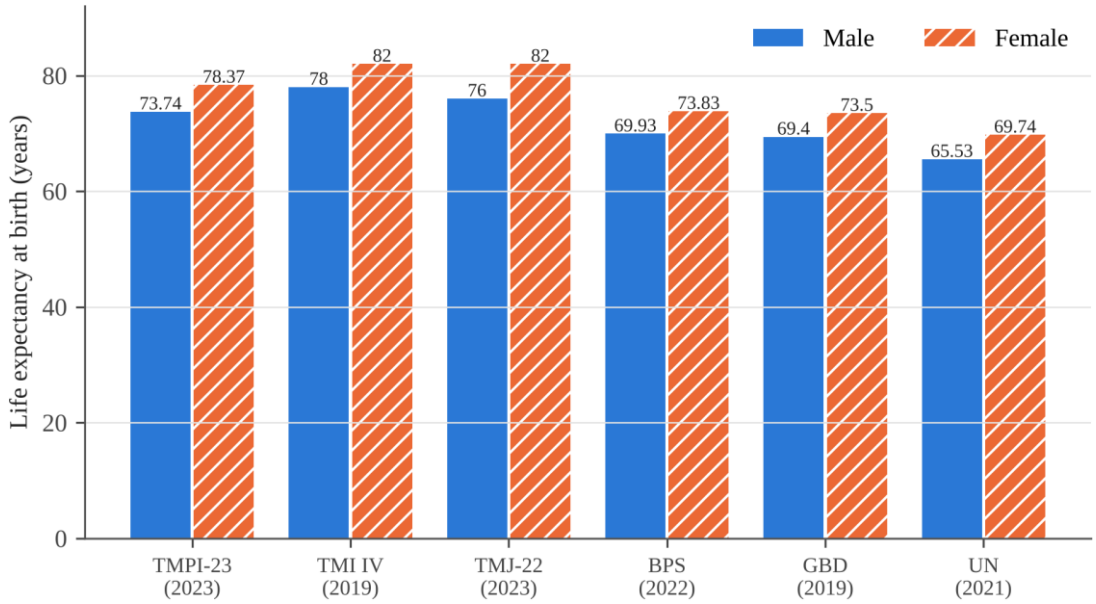


Figure 6. Life Expectancy at Birth by Mortality Table or Source and Sex

Relative to TMI IV, TMPI-23 implies 4.26 fewer years of life at birth for males and 3.63 fewer years for females. Relative to TMJ-22, the difference is 2.26 years for males and 3.63 years for females. These differences arise from the age range in which most life-years are lost. According to the comparative analysis in the source publication, TMPI-23 probabilities of death are higher than those of TMI IV at all ages below about 80 to 81 for both sexes, and higher than those of TMJ-22 below about 81 for males and outside ages 79–95 for females; only at the oldest ages is TMPI-23 mortality lower (BPJS Kesehatan, 2023). Because deaths below age 80 remove many more potential life-years than deaths at very old ages, the higher mortality of TMPI-23 at younger and middle ages dominates, and life expectancy at birth is correspondingly lower.

The ordering TMI IV > TMJ-22 > TMPI-23 is an expression of selection. Insured lives in TMI IV have passed medical and financial underwriting and are drawn disproportionately from higher socio-economic groups; the healthy-worker effect raises the survival of formal-sector employees in TMJ-22; and TMPI-23, which covers nearly the entire population, includes the informal sector, the poor whose contributions are subsidised by the state, and people with pre-existing illness. The finding that the national table lies below the insured-lives table agrees with the evidence of Setiady and Kusnadi (2024) that mortality among older Indonesians in national data far exceeds that of TMI IV. The comparison also explains why the source publication combined crude JKN rates with TMI IV through partial credibility, and why both the TMI IV publication and the TMPI-23 volume note that an insured-lives table cannot represent the mortality of the population as a whole (AAJI, 2019; BPJS Kesehatan, 2023).

At the same time, TMPI-23 yields a life expectancy at birth about 3.8 years higher than Statistics Indonesia for males and about 4.5 years higher for females, and considerably higher than the United Nations and Global Burden of Disease estimates. Two features of the table contribute to this difference. The first is the low mortality at the oldest ages. The second is the potential under-reporting of deaths in administrative data: the source publication reports that the number of JKN participants at old ages exceeded the projected population, with a penetration of 158.70 percent among older women, a pattern consistent with deceased persons remaining on the membership rolls (BPJS Kesehatan, 2023). Unrecorded deaths inflate the exposure and depress the estimated probabilities of death at advanced ages, which in turn lengthens life expectancy at birth and produces the old-age deceleration seen in Figures 1 and 5. The source publication itself recommends periodic re-estimation and further validation of

death data to reduce under-reporting (BPJS Kesehatan, 2023). Readers should therefore treat TMPI-23 old-age mortality, and to a lesser extent its life expectancy at birth, as plausible lower and upper bounds, respectively, rather than as precise values.

Actuarial Implications of the Survival Pattern

To illustrate how the survival pattern translates into actuarial values, Table 9 reports the actuarial present value of a whole-life annuity-due of one unit and the net single premium of a whole-life insurance of one unit, calculated from TMPI-23 at an interest rate of 6 percent. At age 65, the annuity value is 10.60 for males and 11.79 for females, so that a life annuity for a 65-year-old woman costs about 11 percent more than for a man of the same age. Conversely, the net single premium for whole-life insurance at age 40 is 0.162 for males and 0.135 for females, about one-fifth higher for males. These values follow mechanically from the survival probabilities and illustrate how differences in tables of the magnitude documented above affect the pricing of insurance and annuities (Bowers et al., 1997; Dickson et al., 2020).

Table 9. Whole-Life Annuity-Due and Whole-Life Insurance Values at $i = 6\%$, TMPI-23

Age (x)	$\ddot{a}_x$ Male	$\ddot{a}_x$ Female	A_x Male	A_x Female
20	16.5383	16.7122	0.0639	0.0540
40	14.8040	15.2813	0.1620	0.1350
60	11.5067	12.5681	0.3487	0.2886
65	10.6024	11.7859	0.3999	0.3329

Table 10. Sensitivity of Actuarial Values to the Interest Rate, TMPI-23

Interest rate	$\ddot{a}_{65}$ Male	$\ddot{a}_{65}$ Female	A_{40} Male	A_{40} Female
4%	12.4603	14.1385	0.2704	0.2348
6%	10.6024	11.7859	0.1620	0.1350
8%	9.2089	10.0715	0.1054	0.0858

Table 10 shows how these values respond to the valuation interest rate. At an interest rate of 4 percent, the annuity value at age 65 rises to 12.46 for males and 14.14 for females, whereas at 8 percent it falls to 9.21 and 10.07. The net single premium for whole-life insurance at age 40 is even more sensitive, ranging from 0.270 to 0.105 for males and from 0.235 to 0.086 for females as the interest rate increases from 4 to 8 percent. The relative difference between the sexes is, however, broadly stable across interest rates: the female annuity value exceeds the male value by 9 to 14 percent, and the male insurance premium exceeds the female premium by 15 to 23 percent. This confirms that the mortality basis and the interest basis interact, and it is consistent with the strong sensitivity of reserves to the policy rate documented for TMI IV by Deswan et al. (2026) and with the stochastic interest-rate approach of Romantica et al. (2026). For a full valuation, the choice of mortality table must therefore be considered jointly with the economic assumptions rather than in isolation.

The comparison with TMI IV and TMJ-22 has two direct consequences for practice. For death benefits, using the insured-lives table for a population that is closer to the general population would understate the probability of death at working ages and therefore understate premiums and reserves. This risk is relevant to group and micro-insurance products sold without full underwriting and to the social security programmes whose members join without risk selection. Studies that price products on TMI IV, including those on prospective, benefit, and endowment reserves (Prionggo et al., 2022; Wardah et al., 2024; Sadli & Sari, 2025; Suyanto & Felita, 2026), implicitly assume an underwritten population; for unselected populations, the results of this study suggest that TMPI-23 or TMJ-22, with appropriate adjustments, would be the more prudent basis. For survival benefits such as annuities and

pensions, the conclusion is reversed. Here, the relevant risk is that pensioners live longer than assumed, and the higher old-age survival of TMI IV and TMJ-22, combined with the possibility that the low old-age mortality of TMPI-23 is partly an artefact of under-reported deaths, calls for careful selection of the old-age portion of the table and for explicit allowance for future mortality improvement through projection models of the Lee–Carter or Cairns–Blake–Dowd type (Lee & Carter, 1992; Cairns et al., 2006; Pitacco et al., 2009).

Implications for Social Security and Population Ageing

The survival pattern of TMPI-23 has implications beyond the pricing of individual contracts. For the National Health Insurance programme itself, the concentration of deaths in late middle and old age implies that health expenditure will increasingly be driven by chronic disease among people who survive into their sixties and seventies. The source publication emphasises that TMPI-23 is intended to support the actuarial assumptions used to assess contribution adequacy and benefit sufficiency of the JKN programme and to inform health policy and epidemiological analysis (BPJS Kesehatan, 2023). The present results quantify the survival component of that assumption set: for example, about four in five newborns are expected to survive to age 60, and those reaching 65 can expect to live a further 17.6 (males) to 21.4 (females) years.

For the employment social security system, which operates old-age, pension, and death benefit programmes for workers, the relevant population is that of TMJ-22, whose life expectancy at birth is higher than that of TMPI-23. The difference reflects the healthier composition of formal-sector workers and suggests that projections of pension liabilities based on population-wide mortality would understate the duration of benefit payments to that membership. Conversely, if coverage is extended to informal and lower-income workers, as social security policy aims to do, the mortality of the covered population is likely to move towards that of TMPI-23, with corresponding consequences for the balance between death and survival benefits (BPJS Ketenagakerjaan, 2023; Republik Indonesia, 2004).

For commercial insurers supervised under the Insurance Law (Republik Indonesia, 2014), the main lesson is that TMI IV is appropriate for fully underwritten individual business but not for group, mass-market, or simplified-issue products, where the insured population resembles the general population more closely. Products for these segments, including Islamic insurance schemes in which participants' contributions finance mutual assistance funds (Prabowo, 2022b), would be priced more prudently on TMPI-23 or on a blend of TMPI-23 and TMI IV calibrated to the expected degree of selection. More generally, the coexistence of three official tables with life expectancies at birth that differ by up to four years for the same country calls for a transparent framework for table selection, in which the choice of table is justified by the characteristics of the covered population and documented in actuarial reports.

Discussion

The results answer the research questions in several ways. First, the survival function of the Indonesian population as described by TMPI-23 is characterised by low mortality in childhood and young adulthood, a steep increase from the late forties, and a strong concentration of deaths in late middle and old age. About three-quarters of men and four-fifths of women survive from birth to 65, but fewer than half of men survive to 80. These are the core quantities that determine the expected duration of contribution and benefit periods in insurance and social security programmes.

Second, the persistent female advantage, a gap of 4.6 years at birth and nearly 4 years at 65, has direct implications for gender-specific pricing and for the fairness of unisex arrangements. Excess male mortality is concentrated in late middle age, exactly the period in which the Gompertz law underestimates mortality. This suggests that a substantial share of the

sex gap is attributable to premature adult deaths from preventable chronic disease rather than to differences in senescence alone, which links actuarial evidence to the public health agenda.

Third, the near-exponential increase in adult mortality confirms the continuing relevance of the classical laws for Indonesian data, but the absence of a Makeham constant and the deceleration at old ages show that a single parametric curve cannot represent the full adult age range of TMPI-23. Indonesian studies that use Gompertz or Makeham versions of TMI IV for pricing (Prabowo, 2022a; Nurhaliza et al., 2025; Febry et al., 2026) should be interpreted with this caveat in mind, particularly for products whose value depends on survival to very old ages. Model life tables (Coale et al., 1983), interpolation methods for abridged data (Khaliludin et al., 2019), and the survivorship approach applied to Indonesian male mortality by Puspita et al. (2020) offer alternative routes to complete tables where reliable single-age data are scarce.

Fourth, the comparison across tables demonstrates that there is no single Indonesian life expectancy for actuarial purposes. Depending on the reference population, life expectancy at birth ranges from about 74 to 78 years for males and from about 78 to 82 years for females across the three actuarial tables, and down to about 66 and 70 years in the international estimates. These differences are large relative to the sensitivities of insurance and pension values and should be treated as a source of basis risk in their own right. In the long run, the gradual rise of life expectancy documented internationally (Oeppen & Vaupel, 2002) and the ageing of the Indonesian population imply that all three tables will need to be supplemented by projected mortality improvement, using approaches such as those of Brouhns et al. (2002) and Renshaw and Haberman (2006), rather than treated as static.

The results also connect with the international debate on the limits of human longevity. Proponents of the compression-of-morbidity hypothesis argued that the distribution of ages at death would become increasingly concentrated around a biological limit (Fries, 1980), and estimates of the upper limit of life expectancy suggested that gains beyond the mid-eighties would be difficult to achieve (Olshansky et al., 1990). The subsequent evidence of a persistent linear rise in best-practice life expectancy (Oeppen & Vaupel, 2002) indicates that such limits have repeatedly been exceeded. Indonesia remains well below best-practice levels: the TMPI-23 modal ages at death of 88 for males and 94 for females lie far above the corresponding life expectancies at birth, which shows that a considerable share of deaths still occurs before the typical length of life is reached. From an actuarial perspective, this gap is the reservoir from which future mortality improvement will come, and it is precisely the type of improvement that dynamic mortality models are designed to project (Lee & Carter, 1992; Cairns et al., 2006).

The study has several limitations. The comparison with TMI IV and TMJ-22 relies on the life expectancy at birth and on qualitative descriptions of crossing ages reported in the TMPI-23 volume, because the age-specific probabilities of the two comparison tables were not available to the authors. A full age-by-age comparison of survival probabilities and annuity values across the three tables is therefore left for future research. TMPI-23 itself is a period table based on five years that include the COVID-19 pandemic, and its old-age mortality may be affected by under-reported deaths. The actuarial values are calculated at a single illustrative interest rate and do not include expenses or mortality improvement. Despite these limitations, the analysis provides the first comprehensive actuarial description of survival and life expectancy based on the near-universal Indonesian population table and quantifies its relationship to the tables that currently dominate actuarial practice.

Several directions for future research follow from these limitations. First, an age-by-age comparison of TMPI-23, TMI IV, and TMJ-22 would make it possible to compute survival probabilities, annuity values, and reserves on each basis and to decompose the differences in life expectancy into contributions from specific age groups. Second, the old-age portion of TMPI-23 could be re-estimated after linking JKN membership records more completely to civil registration, or blended with parametric extrapolations such as those based on the Gompertz or Heligman–Pollard laws, to test the sensitivity of annuity values to the treatment of the oldest

ages. Third, subsequent editions of TMPI, if produced periodically as the source publication recommends, would allow the estimation of mortality improvement rates for the Indonesian population and the calibration of stochastic mortality models of the Lee–Carter family (Lee & Carter, 1992; Brouhns et al., 2002; Renshaw & Haberman, 2006). Fourth, the construction of sub-national or segment-specific tables, for example by region of residence or membership segment, would reveal the heterogeneity hidden behind national averages, which the frailty perspective of Vaupel et al. (1979) suggests is substantial. Finally, applying the population table to the pricing of specific Indonesian products, following the methodological templates of earlier premium and reserve studies (Lestari et al., 2024; Suryamika & Novika, 2024; Suyanto & Felita, 2026), would show how much the choice of table matters in practice.

CONCLUSION

This study reconstructed and analysed the 2023 Indonesian Population Mortality Table (TMPI-23) and compared its implied life expectancy with those of the Indonesian Mortality Table IV (TMI IV) and the 2022 Social Security Mortality Table (TMJ-22). The reconstructed tables reproduce the published values exactly, with life expectancy at birth of 73.74 years for males and 78.37 years for females. The probability of surviving from birth to age 65 is 0.739 for males and 0.791 for females, the probability of surviving from 20 to 65 is 0.757 and 0.807, and the median age at death is 77.2 and 83.3 years, respectively. Female life expectancy exceeds male life expectancy at every age, by 4.63 years at birth and 3.76 years at age 65. Adult mortality between ages 30 and 90 follows the Gompertz law closely, with mortality doubling every 9.4 years for males and 10.3 years for females, whereas the Makeham constant is not supported by the data and old-age mortality decelerates relative to the exponential pattern. Life expectancy at birth under TMPI-23 is 4.26 years (males) and 3.63 years (females) lower than under TMI IV and 2.26 and 3.63 years lower than under TMJ-22, reflecting the selection inherent in insured and employed populations, while it is higher than the estimates of Statistics Indonesia and international agencies, partly because of low recorded mortality at advanced ages. It is recommended that actuaries pricing death benefits for unselected populations use TMPI-23 or TMJ-22 rather than TMI IV, that the old-age portion of TMPI-23 be validated and possibly blended with other sources before it is used for annuity and pension valuation, and that future research compare the three tables age by age and incorporate stochastic mortality projections.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used Claude (Anthropic) in order to assist with literature organisation, life-table calculations, figure preparation, and English-language drafting and translation. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

ACKNOWLEDGMENTS

The authors thank BPJS Kesehatan for making the TMPI-23 mortality tables publicly available, and the Indonesian Life Insurance Association and BPJS Ketenagakerjaan for publishing the TMI IV and TMJ-22 tables that made this comparative analysis possible.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Methodology; Formal analysis; Writing - original draft.
Author 2: Data curation; Investigation; Visualization; Validation.

Author 3: Supervision; Writing - review and editing.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Asosiasi Asuransi Jiwa Indonesia. (2019). *Tabel Mortalitas Indonesia IV*. Asosiasi Asuransi Jiwa Indonesia. https://aaji.or.id/File/Download/1970

Asosiasi Asuransi Jiwa Indonesia, Persatuan Aktuaris Indonesia, & Swiss Re. (2012). *Tabel Mortalita Indonesia 2011*. Asosiasi Asuransi Jiwa Indonesia.

Badan Pusat Statistik. (2024). *Angka harapan hidup (AHH) menurut provinsi dan jenis kelamin, 2022–2023*. Badan Pusat Statistik. https://www.bps.go.id

Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). *Actuarial mathematics* (2nd ed.). Society of Actuaries.

BPJS Kesehatan. (2023). *Tabel mortalitas penduduk Indonesia volume 1, 2023 (TMPI-23)*. Kedeputian Bidang Aktuaria, BPJS Kesehatan.

BPJS Ketenagakerjaan. (2023). *Tabel Mortalitas BPJS Ketenagakerjaan Tahun 2022 (TMJ-22)*. BPJS Ketenagakerjaan.

Brouhns, N., Denuit, M., & Vermunt, J. K. (2002). *A Poisson log-bilinear regression approach to the construction of projected lifetables*. Insurance: Mathematics and Economics, 31(3), 373–393. https://doi.org/10.1016/S0167-6687(02)00185-3

Cairns, A. J. G., Blake, D., & Dowd, K. (2006). *A two-factor model for stochastic mortality with parameter uncertainty: Theory and calibration*. Journal of Risk and Insurance, 73(4), 687–718. https://doi.org/10.1111/j.1539-6975.2006.00195.x

Coale, A. J., Demeny, P., & Vaughan, B. (1983). *Regional model life tables and stable populations* (2nd ed.). Academic Press.

Deswan, M. L. U., Zahra, H., & Putri, A. K. (2026). *Analisis sensitivitas cadangan prospektif asuransi jiwa seumur hidup terhadap fluktuasi BI-Rate berdasarkan Tabel Mortalitas Indonesia IV*. Panthera: Jurnal Ilmiah Pendidikan Sains dan Terapan, 6(2), 1384–1393. https://doi.org/10.36312/panthera.v6i2.1270

Dickson, D. C. M., Hardy, M. R., & Waters, H. R. (2020). *Actuarial mathematics for life contingent risks* (3rd ed.). Cambridge University Press.

Fauziah, I., & Amalia, A. (2024). *Semicontinuous endowment insurance premium valuation using quadratic fractional age assumptions*. Desimal: Jurnal Matematika, 7(1), 51–62.

Febry, I. A., Riaman, R., & Firman, S. (2026). *Comparative analysis of endowment life insurance premium reserves using the Canadian method based on the 2019 TMI and Gompertz's law*. International Journal of Business, Economics and Social Development, 7(2), 244–249. https://doi.org/10.46336/ijbesd.v7i2.1177

Fries, J. F. (1980). *Aging, natural death, and the compression of morbidity*. New England Journal of Medicine, 303(3), 130–135. https://doi.org/10.1056/NEJM198007173030304

Futami, T. (1993). *Matematika asuransi jiwa* (Bagian I; G. Herliyanto, Trans.). Oriental Life Insurance Cultural Development Center.

Gerber, H. U. (1997). *Life insurance mathematics* (3rd ed.). Springer.

Gompertz, B. (1825). *On the nature of the function expressive of the law of human mortality, and on a new mode of determining the value of life contingencies*. Philosophical Transactions of the Royal Society of London, 115, 513–583. https://doi.org/10.1098/rstl.1825.0026

Heligman, L., & Pollard, J. H. (1980). *The age pattern of mortality*. Journal of the Institute of Actuaries, 107(1), 49–80.

Kaplan, E. L., & Meier, P. (1958). *Nonparametric estimation from incomplete observations*. Journal of the American Statistical Association, 53(282), 457–481.

Khaliludin, N. I. A., Mohd Khalid, Z., & Abd. Rahman, H. (2019). *On estimate of Malaysian mortality rates using interpolation methods*. Matematika: MJIAM, 35(2), 177–186. https://doi.org/10.11113/matematika.v35.n2.1169

Lee, R. D., & Carter, L. R. (1992). *Modeling and forecasting U.S. mortality*. Journal of the American Statistical Association, 87(419), 659–671.

Lestari, D. A., Simbolon, K., & Tambunan, S. M. P. (2024). *Menentukan nilai premi tunggal bersih asuransi jiwa seumur hidup menggunakan TMI IV tahun 2019 dengan variasi uang pertanggungan (UP)*. Jurnal Riset Rumpun Matematika dan Ilmu Pengetahuan Alam, 3(1), 105–118. https://doi.org/10.55606/jurrimipa.v3i1.2276

Macdonald, A. S., Richards, S. J., & Currie, I. D. (2018). *Modelling mortality with actuarial applications*. Cambridge University Press.

Makeham, W. M. (1860). *On the law of mortality and the construction of annuity tables*. Journal of the Institute of Actuaries, 8(6), 301–310.

Nurhaliza, A., Susanti, D. S., & Lestia, A. S. (2025). *Perbandingan hukum mortalitas Gompertz dan Makeham dalam konstruksi Tabel Mortalitas Indonesia IV*. Jurnal Gaussian, 14(2). https://ejournal3.undip.ac.id/index.php/gaussian/article/view/51048

Oeppen, J., & Vaupel, J. W. (2002). *Broken limits to life expectancy*. Science, 296(5570), 1029–1031. https://doi.org/10.1126/science.1069675

Olshansky, S. J., Carnes, B. A., & Cassel, C. (1990). *In search of Methuselah: Estimating the upper limits to human longevity*. Science, 250(4981), 634–640. https://doi.org/10.1126/science.2237414

Pitacco, E., Denuit, M., Haberman, S., & Olivieri, A. (2009). *Modelling longevity dynamics for pensions and annuity business*. Oxford University Press.

Prabowo, A. (2022a). *Konstruksi tabel mortalitas untuk laki-laki menggunakan hukum Makeham dengan mengacu pada TMI 2019*. Perwira Journal of Science & Engineering, 2(2), 37–42.

Prabowo, A. (2022b). *Penentuan besar dana tabarru' berdasarkan Tabel Mortalitas Indonesia 2019 dan hukum de Moivre*. Perwira Journal of Science & Engineering, 2(2), 21–27.

Pratiwi, A., Satyahadewi, N., & Perdana, H. (2022). *Analisis perhitungan premi asuransi jiwa dengan metode Kostaki melalui model apportionable fractional premiums*. Bimaster: Buletin Ilmiah Matematika, Statistika dan Terapannya, 11(2).

Preston, S. H., Heuveline, P., & Guillot, M. (2001). *Demography: Measuring and modeling population processes*. Blackwell.

Prionggo, E. A., Pratama, M. N., NL, A., & Indrayatna, F. (2022). *Estimation of prospective benefit reserve based on gross premium valuation method using Indonesian Mortality Table IV and De-Moivre assumptions*. Enthusiastic: International Journal of Applied Statistics and Data Science, 2(2), 56–67. https://doi.org/10.20885/enthusiastic.vol2.iss2.art1

Promislow, S. D. (2015). *Fundamentals of actuarial mathematics* (3rd ed.). Wiley.

Puspita, H. D., Prasetya, N. H., & Husein, I. (2020). *Estimation of Indonesian male life table with survivorship probability method in smoothed way by using Coale-Demeny's life table*. Zero: Jurnal Sains, Matematika, dan Terapan, 4(2), 65–70.

Renshaw, A. E., & Haberman, S. (2006). *A cohort-based extension to the Lee–Carter model for mortality reduction factors*. Insurance: Mathematics and Economics, 38(3), 556–570. https://doi.org/10.1016/j.insmatheco.2005.12.001

Republik Indonesia. (2004). *Undang-Undang Nomor 40 Tahun 2004 tentang Sistem Jaminan Sosial Nasional*.

Republik Indonesia. (2014). *Undang-Undang Nomor 40 Tahun 2014 tentang Perasuransian*.

Romantica, K. P., Johan, A. H., Jayanegara, A., & Leo, J. F. (2026). *Whole life insurance utilizing the commissioners method and the Vasicek interest rate model for premium reserve analysis*. Barekeng: Jurnal Ilmu Matematika dan Terapan, 20(2), 1001–1018. https://doi.org/10.30598/barekengvol20iss2pp1001-1018

Sadli, W. H., & Sari, D. P. (2025). *Estimation of benefit reserves in endowment insurance using the Indonesian Mortality Table IV and Zillmer method*. Barekeng: Jurnal Ilmu Matematika dan Terapan, 19(3), 1737–1746. https://doi.org/10.30598/barekengvol19iss3pp1737-1746

Setiady, G. A., & Kusnadi, F. (2024). *Indonesian national mortality rates using the Whittaker-Henderson graduation method*. JTAM (Jurnal Teori dan Aplikasi Matematika), 8(4), 1292–1303. https://doi.org/10.31764/jtam.v8i4.26316

Suryamika, P. E., & Novika, F. (2024). *Rancang produk asuransi jiwa berjangka dengan metode Kostaki melalui model true fractional premiums*. Pythagoras: Jurnal Program Studi Pendidikan Matematika, 13(2), 146–156.

Suyanto, J., & Felita, P. (2026). *Prospective premium reserve for life insurance based on the gross premium valuation method and TMI IV assumptions*. International Journal of Mathematics, Statistics, and Computing, 4(1), 15–23. https://doi.org/10.46336/ijmsc.v4i1.293

Vaupel, J. W., Manton, K. G., & Stallard, E. (1979). *The impact of heterogeneity in individual frailty on the dynamics of mortality*. Demography, 16(3), 439–454. https://doi.org/10.2307/2061224

Wardah, N. H., Putri, N. S. R., Felita, P., Suyanto, J., Indrayatna, F., & Setyanto, G. R. (2024). *Cadangan prospektif asuransi jiwa diskrit dengan metode GPV dan asumsi TMI IV*. In Prosiding Seminar Nasional Statistika Aktuaria III (pp. 206–214). Departemen Statistika FMIPA Universitas Padjadjaran.

Copyright Holder :
© Name Author et al. (2026).
First Publication Right :
© Ingenium Journal of Science, Technology and Business (IJSTB)
This article is under: