UNP JOURNAL MANAGEMENT CENTER

math.ppj.unp.ac.id
p-ISSN 2716-0726
e–ISSN 2716-0734

Indexed

Life Insurance Premium Calculation Using Markov Chain for Hypertension Patients in Indonesia

Fenni Kurnia Mutiya[1] and Marsika Sepyanda[2]

[1] Department of Statistics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang

[2] Department of Sport Science, Faculty of Sport Science, Universitas Negeri Padang

Article History
Received: May 8, 2025 | **Revised**: Sep 3, 2025 | **Accepted**: Sep 18, 2025 | **Published Online**: Apr 30, 2026

Subject Areas:
Life Insurance Premium, Finance, Health Insurance Risk, Mathematical Industry, Stochastic

Keywords:
life insurance, hypertension, Markov chain, annuity as a rider benefit, annual premium.

Author for correspondence:
Fenni Kurnia Mutiya
e-mail: fennikurnia@unp.ac.id

DOI:
https://doi.org/10.24036/rmj.v5i1.84

How to Cite:
Mutiya, F., K., & Sepyanda, M. (2026). Life Insurance Premium Calculation Using Markov Chain for Hypertension Patients in Indonesia. *Rangkiang Mathematics Journal*, 5(1), 11-19.
https://doi.org/10.24036/rmj.v5i1.84

Abstract- Long-term care insurance provides death benefits if the insured dies and benefits for medical care costs during the coverage term. One of the products of this insurance is the Annuity Rider, as the Benefit can be modelled with a multi-state model. This paper discusses the calculation of annual premiums with Annuity riders as a Benefit product using a multi-state model for hypertension patients in Indonesia. The premium calculation also utilised Markov Chain transition probabilities. The data used in the Report Survey Kesehatan Indonesia in 2023. The case study was conducted on a 40-year-old male in good health, with LTC insurance coverage for 5 years. It was known that the compensation amount for someone who died was IDR 200,000,000, and the interest rate was 7%. By calculating premiums using the multi-state model, the results yielded an annual premium of IDR 6,486,998. The result of this premium calculation is that the older someone is when they take out insurance, the greater the annual net premium they must pay.

1. Introduction

Insurance is one of the non-bank financial institutions that protects against financial losses arising from unexpected events (Keuangan, Peraturan Otoritas Jasa Keuangan Republik Indonesia Nomor 20 Tahun 2023, 2023). The primary function of insurance is to facilitate the transfer of risk from the insured to the insurer. This risk transfer process does not eliminate the possibility of adverse events; instead, it provides the insured with financial security and peace of mind. One of the key activities in insurance is the payment of premiums by the insured as compensation for the financial protection services provided by the insurer (RT, 2014).

Various studies have been conducted to advance actuarial science, particularly in life insurance. Life insurance is a type of insurance product that provides risk transfer benefits in the event of an individual's loss of economic value. These benefits typically involve a lump-sum payment to the insured's family or legal heirs, as stipulated in the insurance policy. The Markov Chain is a stochastic model for predicting future states based solely on the current state, without influence from past conditions. One of the multi-state models in long-term care (LTC) insurance is the Annuity-as-a-Rider Benefit. LTC insurance is designed to provide financial protection for policyholders who require long-term medical care, particularly those suffering from chronic illnesses or disabilities. The Annuity as a Rider Benefit product offers periodic payments to cover medical care costs over a specific period and provides a death benefit if the insured passes away (RT, 2014).

According to Rickayzen, B. D., & Walsh, D. E. P. (2002), the authors successfully quantified the expected time that elderly individuals would spend in different states of disability, providing crucial data for pricing LTC insurance. It concluded that multi-state models are superior to simple binary (healthy or dead) models for forecasting care needs and costs, as they capture the nuances of progressive disability. According to Pitacco (2014), a Markovian multi-state framework is the most appropriate and flexible structure for pricing and reserving disability and LTC products. It emphasised the need to use period-specific (and ideally population-specific) transition intensities rather than static probabilities to reflect evolving mortality and morbidity patterns. According to Levantesi, S., & Menzietti, M. (2012), bundling LTC coverage with a life annuity within a single product can significantly reduce overall risk for the insurer compared to selling the policies separately. The Markov model was essential for quantifying this risk reduction, demonstrating that such combined products are not only viable but also more stable for insurers and more comprehensive for consumers. According to Czado, C., & Rudolph, F. (2002), the inclusion of covariates is essential for creating realistic and predictive models. By accounting for time trends ("longevity drift"), the models become dynamic and forward-looking, leading to premium and reserve calculations that remain accurate over the long duration of LTC policies, thereby protecting insurer solvency. According to Christiansen, M. C. (2012), Markov chains are indispensable not just for pricing, but for ongoing financial stability. They enable insurers to calculate the precise reserve amount that must be held today for each policyholder based on their current health state. This ensures that funds are available to pay all future claims, whether the beneficiary is currently healthy or already receiving care.

This study examines the transition of policyholders from state 1 to other states within a given period. Changes in the health status of policyholders in long-term life insurance can be represented using a multi-state model. Accurate premium calculations for LTC insurance products, particularly the Annuity as a Rider Benefit, ensure that claim payments to policyholders are made smoothly without causing financial losses to the insurance company.

2. Methods

The methods used in this study are Markov chains in a stochastic model for multistate long-term care insurance.

(a) Data

According to Indonesia's Ministry of Health, non-communicable diseases classified as chronic illnesses include hypertension, diabetes mellitus, cardiovascular diseases (hypertension and stroke), cancer, and chronic respiratory diseases (chronic obstructive pulmonary disease, asthma, etc.). The data used in this study are from the 2023 Indonesia Health Survey Report (SKI), specifically the prevalence of hypertension based on doctor diagnoses among individuals aged 15 years and older. The data are categorised by age groups, requiring linear interpolation to estimate the prevalence rate for each age group among hypertension patients. A transition probability matrix is constructed for the multi-state model, and key factors such as the insured's age, benefit amount, and coverage duration are determined to calculate the monthly premiums for long-term insurance products, as shown in Table 1.

$$Hypertension\ prevalence\ based\ on\ doctor\ diagnosis: = \frac{Household\ members\ aged\ \geq 15\ years\ diagnosed\ with\ hypertension\ by\ a\ doctor}{Household\ members\ aged\ \geq 15\ years\ interviewed}$$

Table 1. Hypertension Prevalence Based On Doctor Diagnosis, SKI 2023

Age Group (Years)	Hypertension (%)
18 – 24	0,4
25 – 34	1,8
35 – 44	5,2
45 – 54	11,8
55 – 64	18,7
65 – 74	23,8
75 +	26,1
Gender	
Male	5,9
Female	11,2
Average	8,55

(b) Linear Interpolation

Interpolation is a method used to determine the value of a function at points where its graph passes through a set of known points. These points may be obtained from experimental data or derived from a known function. Linear interpolation, in particular, is a technique used to find values between two known points by applying a linear equation (a straight line) (Bowers, 1997). The formula for linear interpolation is in Equation 1.

$$\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1} \tag{1}$$

x = the age to be interpolated
x_1 = the lower bound of the age group where age x belongs
x_2 = the upper bound of the next age group after x
y = the prevalence rate for age x
y_1 = the prevalence rate of the age group where age x belongs
y_2 = the prevalence rate of the age group after the group where age x belongs

(c) Stochastic Process

A stochastic process is a set of random variables that function over time. The set of possible values for a random variable Xt in a stochastic process $\{Xt, t \in T\}$ is called the state space. A stochastic process $\{Xt; t \in T\}$ is a collection of random variables, where Xt represents a random variable, and t serves as an index or time parameter within T. (Bowers, 1997). The set TT is the index set that defines the parameter space. If the index set T is continuous, then $\{Xt; t \in T\}$ is called a continuous-time stochastic process. If the index set TTT consists of countable numbers from a number line, then $\{X(t), t \in T\}$ is a discrete-time stochastic process (Bowers, 1997).

A Markov process is a stochastic process in which the past does not influence the future once the present state is known. This means that the outcome of a Markov process depends only on the current state and not on previous events. Stochastic behaviour often appears in probabilistic events.
A stochastic process $\{X(0), X(1), \dots, X(k+1)\}$)}, where observations are made at sequential time points $0,1, \dots, k+1$ is classified as a Discrete-Time Markov Chain (DTMC) if it satisfies the conditional probability distribution equation (conditional pdf) for all $k \in K$ and for all $hi \in S$ in Equation 2.

$$P(X(k+1) = hk+1 \mid X(k) = hk, X(k-1) = hk-1, \ldots, X(0) = h0) = P(X(k+1) = hk+1 \mid X(k) = hk) \quad (2)$$

Generally, the conditional probability of transitioning from state i at time s to state j at time t is commonly denoted as $Pij(s, t)$. The properties of $Pij(s, t)$ are as follows [4]:

1. $0 \le Pij(s, t) \le 1,$ for all $i, j; 0 \le s \le t$
2. $\sum jPij(s, t) = 1,$ for all $i; 0 \le s \le t$

The Chapman-Kolmogorov equation is a method for calculating the transition probability over h steps, as defined in Equation 3.

$$hPij(s, t) = \sum m \in hPim(s, k).\ Pmj(k, t);\ s \le k \le t \quad (3)$$

Equation (3) describes a path that starts from state i at time s, moves to state j at time t through several intermediate states m continuously at time k.

(d) Discrete – Time Multistate Model

The state space is denoted by S and represents a finite set, defined as: $S = \{1,2,3, \ldots, N\}$ where N is the total number of states used. The transition set is denoted by τ, where τ is a subset of state pairs (i,j): $\tau \subseteq \{(i, j) \mid i \neq j;\ i, j \in S\}$. If state i is the initial state at time 0, it is assumed that all states j ∈ S can be reached from state i via direct transitions in the pair (S, τ), which is referred to as a multi-state model (Li, 2019).

(e) Long Term Care Insurance

Long-Term Care (LTC) insurance provides policyholders with annuity benefits or reimbursement for medical and care expenses. Certain LTC insurance policies also include a lifetime annuity in cases where the insured becomes disabled (OECD, 2020).

The three categories of LTC insurance are:

1. A specified annuity benefit offered to healthy individuals;
2. A specified annuity benefit offered to elderly individuals who are about to enter or are currently undergoing long-term care;
3. Reimbursement of care and medical expenses.

(f) Annuity as A Rider Benefit

An annuity as A Rider Benefit is a Long-Term Care (LTC) insurance product that provides medical care benefits for a specified period and death benefits in the event of the policyholder's passing, whether due to an existing illness or unrelated causes (Kesehatan, 2024).

In the Annuity as A Rider Benefit product, there is no transition from a sick state to a healthy state (as it does not assume recovery). The three states in Annuity as A Rider Benefit for Long-Term Care insurance are:

1. Healthy
2. Hypertension illness
3. Deceased

It can be illustrated in Figure 1.

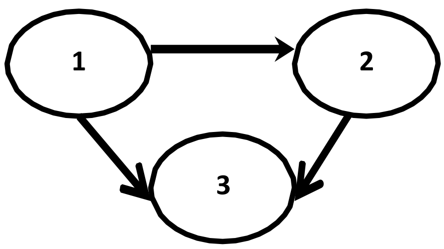

Figure 1. Three–State Model Diagram

(g) Probabilities for the Dicrete – Time Model

Let x denote the policyholder's age at the time of the insurance agreement, and $s(x)$ represent the survival function in a discrete-time Markov Chain. The three states are defined as follows. The illustration of the three-state model can be seen in Figure 1 and can be represented in the form of a transition matrix as follows:

$$P_x = \begin{bmatrix} p_x^{11} & p_x^{12} & q_x^{13} \\ 0 & p_x^{22} & q_x^{23} \\ 0 & 0 & 1 \end{bmatrix}$$

p_x^{11} : The probability that a person aged x years who is currently in a healthy state (1) will remain in a healthy state (1) in the next period.
p_x^{12} : The probability that a person aged x years who is currently in a healthy state (1) will transition to a hypertensive state (2) in the next period.
p_x^{22} : The probability that a person aged x years who is currently in a hypertensive state (2) will remain in a hypertensive state (2) in the next period.
q_x^{13} : The probability that a person aged x years who is currently in a healthy state (1) will transition to death (3) in the next period.
q_x^{23} : The probability that a person aged x years who is currently in a hypertensive state (2) will transition to death (3) in the next period.

The h-step transition probability based on the Markov Chain can be expressed in Equation 4.

$$ {}_hp_x^{11} = Pr(X(x+h) = 1 \mid X(x) = 1)$$
$$ {}_hp_x^{12} = Pr(X(x+h) = 2 \mid X(x) = 1) \quad (4)$$

Thus, the Chapman-Kolmogorov equation is obtained in Equation 5.

$$ {}_hp_x^{11} = {}_{h-1}p_x^{11} + p_{x+h-1}^{11}$$
$$ {}_hp_x^{12} = {}_{h-1}p_x^{12} p_{x+h-1}^{22} + {}_{h-1}p_x^{11} p_{x+h-1}^{12} \quad (5)$$

Equations (4) and (5) can be written in matrix form in Equation 6.

$$P_x = \begin{bmatrix} p_x^{11} & p_x^{12} & q_x^{13} \\ p_x^{21} & p_x^{22} & q_x^{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} p_{x+1}^{11} & p_{x+1}^{12} & q_{x+1}^{13} \\ p_{x+1}^{21} & p_{x+1}^{22} & q_{x+1}^{23} \\ 0 & 0 & 1 \end{bmatrix} \cdots \begin{bmatrix} p_{x+h-1}^{11} & p_{x+h-1}^{12} & q_{x+h-1}^{13} \\ p_{x+h-1}^{21} & p_{x+h-1}^{22} & q_{x+h-1}^{23} \\ 0 & 0 & 1 \end{bmatrix} \quad (6)$$

(h) Benefit Value and Annual Premium

In LTC insurance, one of its products is an Annuity Rider, which provides medical care benefits during the coverage period and death benefits if the insured passes away, whether due to illness or other causes. The transition from status 2 (sick) to status 1 (healthy) does not apply in this type of insurance product. In the three-status model, a benefit amount c is provided as a death benefit, which is a lump sum payment given to the insured's heirs in the event of death. Additionally, a periodic benefit b is paid annually during the insured's care period. It is denoted as $b = \frac{c}{r}$, where r is the maximum duration (in years) for the annuity payment while the insured is undergoing treatment. The duration of annuity benefit payments, from the start of treatment until the insured's death, is denoted by f. The annual discount factor is given by $v = \frac{i}{1+i}$where denotes the interest rate, the net single premium that must be paid at the beginning of each year for LTC insurance over n years is given by Equation 7.

$$A_{x:\overline{n}|}^{LTC} = c\sum_{t=1}^{n} v^t\, {}_{t-1}p_x^{11} q_{x+t-1}^{13} + b\sum_{t=1}^{n}\left\{v^t\, {}_{t-1}p_x^{11} p_{x+t-1}^{12}\left(\ddot{a}_{x+t:r}^{22} + \sum_{h=1}^{\frac{c}{b}}(c-hb)\, v^h\, {}_{h-1}p_{x+t}^{22} q_{x+t+h-1}^{23}\right)\right\} \quad (7)$$

The annual insurance value is in Equation 8.

$$P = \frac{A_{x:\overline{n}|}^{LTC}}{\ddot{a}_{x:\overline{n}|}^{ij}} \quad (8)$$

math.ppj.unp.ac.id Rangkiang Mathematics Journal Vol 5, No. 1, 2026

3. Results and Discussion

(a) Linear Interpolation of Prevalence Data

Based on Table 1, interpolation is performed for each age group using the hypertension prevalence in Indonesia, with the interpolation formula from Equation (1). The interpolation results are displayed in Table 2.

Table 2. Results of Linear Interpolation of Hypertension Prevalence Rate

Age	Prevalence Rate
18	0,0040
19	0,0060
⋮	⋮
35	0,0520
36	0,0586
⋮	⋮
40	0,0850
⋮	⋮
70	0,2495
⋮	⋮
75+	0,2610

(b) Transition Probability Matrix

Based on the results of linear interpolation of prevalence rates in Table 2 and the Indonesian Mortality Table IV, the next step is to calculate the transition probability matrix for h steps using matrix multiplication as in equation (6). The transition probability matrix with three states is as follows:

$$P_x = \begin{bmatrix} p_x^{11} & p_x^{12} & q_x^{13} \\ p_x^{21} & p_x^{22} & q_x^{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} p_{x+1}^{11} & p_{x+1}^{12} & q_{x+1}^{13} \\ p_{x+1}^{21} & p_{x+1}^{22} & q_{x+1}^{23} \\ 0 & 0 & 1 \end{bmatrix} \cdots \begin{bmatrix} p_{x+h-1}^{11} & p_{x+h-1}^{12} & q_{x+h-1}^{13} \\ p_{x+h-1}^{21} & p_{x+h-1}^{22} & q_{x+h-1}^{23} \\ 0 & 0 & 1 \end{bmatrix}$$

Where:

$p_x^{11} = 1 - p_x^{12} - q_x^{13}$

$q_x^{23} = (1+\eta) \cdot q_x^{13}$

$p_x^{22} = 1 - q_x^{23}$

η is a comparative constant value of 5%, as an additional assumption for the mortality rate beyond hypertension.

Suppose a 40-year-old male; the one-step transition probability matrix calculation is as follows:

1. The probability of death for a 40-year-old male based on the Indonesian Mortality Table IV is $q_{40}^{13} =$ 0,00173.
2. The probability that a 40-year-old male will transition from a healthy state (1) to suffering from hypertension (2) in one year is $p_{40}^{12} = 0{,}0850$.
3. The probability that a 40-year-old male who is currently healthy remains healthy one year later is:

$$\begin{aligned} p_{40}^{11} &= 1 - p_{40}^{12} - q_{40}^{13} \\ &= 1 - p_{40}^{12} - q_{40}^{13} \\ &= 1 - 0{,}0850 - 0{,}00173 \\ &= 0{,}9133 \end{aligned}$$

4. The probability of death for a 35-year-old male with hypertension one year later, considering the comparative constant $\eta = 0{,}05$, is:

$$\begin{aligned} q_{40}^{23} &= (1+\eta) \cdot q_{40}^{13} \\ &= (1+0{,}05) \cdot 0{,}00173 \\ &= 0{,}0018 \end{aligned}$$

The one-step transition probability matrix for a 40-year-old male:

$$p_{40} = \begin{bmatrix} 0{,}9133 & 0{,}0850 & 0{,}00173 \\ 0 & 0{,}9982 & 0{,}0018 \\ 0 & 0 & 1 \end{bmatrix}$$

The two-step transition probability matrix for a 40-year-old male is obtained by performing matrix multiplication:

$$
{}_2P_{40} = \begin{bmatrix} p_{40}^{11} & p_{40}^{12} & q_{40}^{13} \\ 0 & p_{40}^{22} & q_{40}^{23} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} p_{41}^{11} & p_{41}^{12} & q_{41}^{13} \\ 0 & p_{41}^{22} & q_{41}^{23} \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
= \begin{bmatrix} 0{,}9133 & 0{,}0850 & 0{,}00173 \\ 0 & 0{,}9982 & 0{,}0018 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 0{,}9065 & 0{,}0916 & 0{,}0019 \\ 0 & 0{,}9980 & 0{,}0020 \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
= \begin{bmatrix} 0{,}8279 & 0{,}1685 & 0{,}0037 \\ 0 & 0{,}9962 & 0{,}0038 \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
P_{40} = \begin{bmatrix} 0{,}8156 & 0{,}1805 & 0{,}0039 \\ 0 & 0{,}9959 & 0{,}0041 \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
P_{40} = \begin{bmatrix} 0{,}8093 & 0{,}1865 & 0{,}0041 \\ 0 & 0{,}9957 & 0{,}0043 \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
{}_5P_{40} = \begin{bmatrix} 0{,}8030 & 0{,}1925 & 0{,}0044 \\ 0 & 0{,}9954 & 0{,}0046 \\ 0 & 0 & 1 \end{bmatrix}
$$

The one-step transition probability matrix can be illustrated in Figure 2.

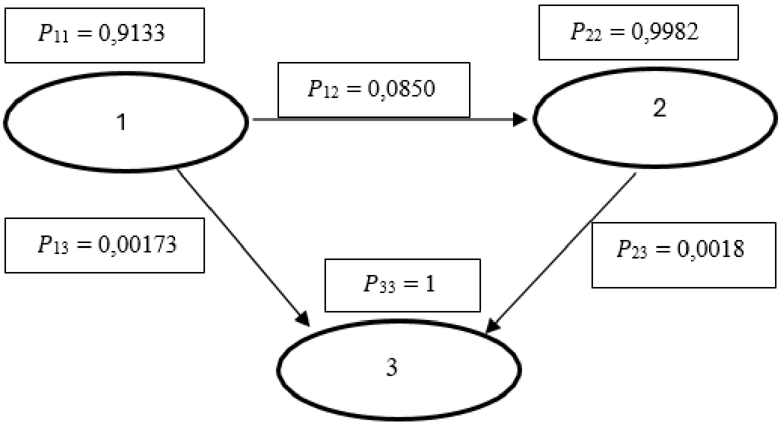

Figure 2. One-Step Transition Matrix Diagram for a 40-Year-Old Male

(c) Annual Premium Calculation for Long Term Care Insurance: Annuity as Rider Benefit

This insurance product provides benefits for individuals aged x years under the following policy conditions:

1. At the time of the policy agreement, the insured (policyholder) is x years old and in good health.
2. If the insured passes away at age x due to reasons other than hypertension (q_x^13), the beneficiary is entitled to a lump sum benefit of c.
3. If the insured is diagnosed with hypertension, they will receive an annual care benefit of b at the beginning of each year for a maximum of r years, where $b = c/r$.
4. If the insured passes away before completing the care benefit period (less than r years), meaning in year h after beginning the care benefit payments (with $h \leq r$), the beneficiary will receive an additional lump sum benefit of $c - b \min(h,r)$.
5. Premium payments are made while the insured remains in a healthy state, either as a lump sum or as annual annuity payments.

In this study, an annual premium calculation will be conducted for a 40-year-old male, with a death benefit of Rp. 200,000,000. The insured will also receive a maximum of 5 years of care benefit payments if diagnosed with hypertension (status 2). Premium payments will be made annually at the beginning of each year for 5 years, as long as the insured remains in status 1 (healthy). The interest rate used is 7%. The annual premium payment required to receive these benefits will be calculated based on Equations

(7) and (8) as follows:

$$A^{LTC}_{40:5]} = 200\ juta \sum_{t=1}^{5} (1+0{,}07)^{-5}\ {}_{t-1}p^{11}_{40} q^{13}_{40+t-1} + 40\ juta \sum_{t=1}^{5} (1+\ 0{,}07)^{-5}\ {}_{t-1}p^{11}_{40} p^{12}_{40+t-1} \ddot{a}^{22}_{40+t:5}$$
$$= Rp.\,25.031.559$$

The annual premium amount is:

$$P = \frac{Rp.\,25.031.559}{3{,}8587} = Rp.\,6.486.998$$

The annual net premium paid for ages 35, 40, and 45, by gender, is shown in Table 3.

Table 3. Annual Net Premium for LTC Insurance Based on Gender and Age Variations

Age	Gender	
	male	Female
35	5,101,744	5,035,893
40	6,486,998	6,343,926
45	7,624,907	7,351,017

Based on Table 3, premium payments increase with age. Additionally, the premium for males is higher than for females, as the probability of death at the same age is higher for males, according to the Indonesian Mortality Table IV (AAIJ, 2019).

4. Conclusion

Based on the calculation results, the annual premium will increase with age. This study calculates the premium for a 40-year-old male with a 5-year premium payment period. The transition matrix obtained for the case study in this research is:

$$P_{40} = \begin{bmatrix} 0{,}8030 & 0{,}1925 & 0{,}0044 \\ 0 & 0{,}9954 & 0{,}0046 \\ 0 & 0 & 1 \end{bmatrix}$$

The annual premium to be paid is IDR 6.486.998. The benefits received by the insured include a death benefit and a care benefit if the insured requires medical treatment due to hypertension.

References

1. AAIJ. (2019). Tabel Mortalitas Indonesia IV. Jakarta: Asosiasi Asuransi Jiwa Indonesia.
2. Bowers, N. G. (1997). Actuarial mathematics. New York: Society of Actuaries.
3. Christiansen, M. C. (2012). Multistate Models in Health Insurance.Ulm: Universitat Ulm.
4. Czado, C., & Rudolph, F. (2002). Application of Survival Analysis Methods to Long-Term Care Insurance. Sonderforschungsbereich 386, Paper 268.
5. E. Karyady, N. Satyahadewi, H. Perdana. (2022). Perhitungan Premi Asuransi Jiwa Dengan Aplikasi Rantai Markov Pada Penderita Penyakit Jantung di Kalimantan Barat. Buletin Ilmiah Math. Stat dan Terapannya (Bimaster). Volume 11, No. 1:167-176.
6. F.K., Mutiya. (2023). Premi Tahunan Asuransi Long Term Care Dwiguna Menggunakan Model Multistate. Jurnal Pendidikan dan Konseling (JPDK).
7. Gumauti CP, Wilandari Y, Rahmawati R. (2016). Perhitungan Premi Asuransi Long Term Care untuk Model Multi Status, Jurnal Gaussian, 5:259-267.
8. Kesehatan, Badan Kesehatan (2023). Survei Kesehatan Indonesia 2023 Dalam Angka. Jakarta: Kementerian Kesehatan Republik Indonesia.
9. Keuangan, Otoritas Jasa Keuangan (2023). Peraturan Otoritas Jasa Keuangan Republik Indonesia Nomor 20 Tahun 2023.
10. Li, J. (2019). A Multi-state Model for Pricing Critical. Canada: SIMON FRASER UNIVERSITY.
11. Levantesi, S., & Menzietti, M. (2012). Managing Longevity and Disability Risks in Life Annuities with Long Term Care. Insurance: Mathematics and Economics, Volume 50, Issue 3,
12. OECD. (2020). Assessing the Comparability of Long-Term Care Spending Estimates under the Joint

Health Accounts Questionnaire. Paris, France: OECD.
13. Pitacco, E. (2014). Health Insurance: Basic Actuarial Models. Springer.
14. Rickayzen, B.D. & Walsh, D.E.P. (2002). A Multi-State Model of Disability for the United Kingdom: Implications for Future Need for Long-Term Care for the Elderly. *British Actuarial Journal, Cambridge University Press*, 8(2), 341-393.
15. RT, Konetzka. (2014). Long Term Care Insurance. In encyclopedia of health Economics, ed. A. J. Culyer, 152-159. In Encyclopedia of health Economic (pp. 152-159). San Diego: Elvisier.
16. Septiani, Siti Rahayu Putri, Kusnandar D., Perdana H. (2022). Model Multi-state untuk Produk Asuransi Long term Care. Buletin Ilmiah Math. Stat dan Terapannya (Bimaster). Volume 11, No. 3:457-460.
17. Taylor, H. Karlin, Samuel. (1994). An Introduction to Stochastic Modelling 3rd Edition. San Diego : Academic Press.

math.ppj.unp.ac.id Rangkiang Mathematics Journal Vol 5, No. 1, 2026