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Calculation of Premium Reserve Value in Whole Life Insurance Using the New Jersey Method

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Abstract

Premium reserves are funds prepared by insurance companies to pay potential future claims. One type of premium reserve calculation is the prospective reserve, where the reserve value is calculated based on the present value of all future expenses minus the present value of total future income. The purpose of this study is to calculate whole life insurance premium reserves based on the participants' age using the New Jersey method. This research adopts a quantitative approach, starting with determining the annuity value based on interest rates and participants' age, followed by calculating the single net premium, annual net premium, continued net premium, and the premium reserve value at the end of year t. The results indicate that the initial age of participants significantly influences the premium reserve value. The older the participant at the start of the insurance, the higher the premium reserve calculated using the New Jersey method.

Keywords: Premium Reserve, Whole Life Insurance, New Jersey Method.

1. Introduction

Financial well-being is one of the aspirations of every individual. However, human life in the future is full of uncertainties. Unexpected risks, such as illness, disasters, death, or material losses, can occur at any time and bring significant financial impacts. According to Sutrisno et al. (2022), risk is the uncertainty of an event occurring that may cause economic loss. To mitigate the impact of such risks, one possible solution is through insurance programs.

Insurance is an agreement between a policyholder (the insured) and an insurance company (the insurer), where financial risks that may occur are transferred from the insured to the insurer in exchange for periodic premium payments. Insurance products come in various types, such as life insurance, health insurance, vehicle insurance, and property insurance. One commonly used type of life insurance is whole life insurance, which provides coverage from the start of the contract until the insured's death (Rahmawati, 2020).

Life insurance companies face various challenges, including the need for funds to pay claims, policy creation, administrative costs, and agent commissions. Therefore, companies need to establish premium reserves to ensure the availability of funds in the future. Premium reserves are funds that companies must set aside to pay for potential claims (Prasetya, 2021). Determining the amount of premium reserves requires accurate calculation methods to help companies mitigate the risk of losses caused by claims exceeding predictions.

There are two main approaches to calculating premium reserves: the prospective method and the retrospective method. The prospective method calculates reserves based on the present value of future expenses minus the present value of future income, while the retrospective method calculates reserves based on past income and expenses (Hidayat, 2019). In this study, the New Jersey method is used as a more accurate approach to calculating premium reserves. This method is an improvement over the Illinois method, particularly for cases where premium payments exceed 20 installments, which often result in inconsistent values.

The New Jersey method provides more effective and accurate results in determining premium reserves for life insurance with periodic premium payments. One of the key factors in this method is the initial age of the insured and the interest rate. Additionally, life and death probabilities found in mortality tables also influence the calculation of premium reserves (Anwar, 2023).

Using the New Jersey method, this study aims to calculate the premium reserve amount for whole life insurance. The results are expected to provide insights for insurance companies in managing premium reserves optimally and avoiding the risk of fund shortages in the future.

2. Literature Review

2.1. Life Insurance

Life insurance is a form of financial protection that provides a sum of money to the family or beneficiaries if the insured person passes away. This money is given according to the agreement stated in the insurance policy and aims to help the family cope with the financial impact of losing the insured (Setiawati et al., 2019).

According to H.M.N. Purwosutjipto, life insurance is a reciprocal agreement between insurance members and the insurance company, where the members commit themselves to pay premiums during the insurance period, while the insurance company, in return, agrees to pay a certain amount to the chosen heirs as a result of the insured person’s death (Fauzi, 2019). Based on Purwosutjipto's explanation of life insurance, it can be concluded that the insurance agreement is reciprocal. The insured commits to paying a premium to the insurer, while the insurer commits to providing a predetermined amount to the heirs as a direct consequence of the policyholder's death.

According to the Indonesian Life Insurance Association (AAJI), the purpose of life insurance is to guarantee unexpected financial needs caused by sudden death or an unexpectedly long life. Essentially, life insurance can be categorized into the following types (Fauzi, 2019):

- Term Life Insurance
  Term life insurance provides compensation (benefits) if the insured dies within the agreed-upon period of coverage. This type of insurance, also known as temporary insurance, is designed to provide life insurance coverage for a specific term. The policy term varies and can be 1 year, 5 years, 10 years, or up to a certain age. The insurer typically issues policies with benefits for total permanent disability (TPD).
- Whole Life Insurance
  This insurance is designed to provide lifetime coverage for the insured (policyholder), provided they keep the policy active by continuously paying premiums. This policy offers comprehensive protection. The benefits of this policy are paid out in a lump sum if the insured passes away or can be paid out in stages or in a lump sum if the insured suffers TPD, depending on the coverage amount. There is no time limit for death protection, but TPD protection will end once the insured reaches a certain age.
- Endowment Insurance
  Endowment insurance consists of two components: savings and life protection. In this policy, the savings component is more dominant, making the policy similar to a savings plan. The protection provided by this policy can be utilized for a specific period.

2.2. Interest

The effective interest rate, denoted by i, is the ratio of the total interest earned in one period to the principal amount invested at the beginning of the period (Sidi, 2008). The present value (v) for a payment of 1 unit made one year later can be expressed as (Larson, 1951):

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

If the payment is made one year earlier, the unpaid interest will amount to $d = 1 - v$, where d represents the effective discount rate. Using equation (1), d can be written as (Larson, 1951):

$$d = \frac{i}{1+i} \tag{2}$$

The amount of interest depends on the principal, the interest rate, and the duration of the investment. Interest is divided into two types: simple interest and compound interest.

Simple Interest

Simple interest is calculated based on a direct proportion between the principal P, the fixed interest rate i, and the investment duration n years. The interest amount can be determined using the equation (Pramudya, 2008):

$$I = Pni \tag{3}$$

Thus, after n years, the total value of the investment becomes:

$$\begin{aligned} S &= P + I \\ &= P(1 + ni) \end{aligned} \tag{4}$$

Compound Interest

Compound interest is a method of calculating interest where the interest for each period is based on the total amount of the loan from the previous period, commonly referred to as "interest on interest" (Pramudya, 2008). For instance, if the principal P is invested in a company using an annual compound interest rate i, the principal plus the interest after n years is calculated as follows:

The interest for the first year is $P \times i$, so the principal plus the interest for the first year is (Larson, 1951):

$$P + Pi = P(1 + i) \tag{5}$$

The interest for the second year is $P(1 + i) \times i$, so the principal plus the interest for the second year is (Larson, 1951):

$$P(1 + i) + P(1 + i)i = P(1 + i)^2$$

Thus, after n years, the principal plus the total interest becomes (Larson, 1951):

$$S = P(1 + i)^n \tag{6}$$

2.3. Mortality Table

In insurance, companies calculate the amount of death benefits, premiums, and other costs based on mortality tables. One of the main objectives of life insurance is to provide financial protection against the loss caused by an individual's death. An accurate tool for estimating the probability of life and death within a specific time frame is a table that records the survival and death data of a population cohort. This table is known as the mortality table.

The mortality table is also referred to as the death table. The probability of a person's death within a given time period is outlined in the death table (Larson, 1951). The life insurance industry utilizes this table to calculate annuities, premiums, and other figures. Mortality tables are instrumental in estimating claims, assessing the likelihood of losses caused by death, and predicting the average life expectancy.

According to Darmawi (2004), the Indonesian Mortality Table contains the following components:

- x = Age
- l_x = Number of individuals alive
- p_x = Probability of survival
- q_x = Probability of death
- d_x = Number of individuals who died

As stated by Larson (1951), the number of individuals born at the same time is denoted by l_0. l_1 represents the group from l_0 who reach the age of one year. l_2 represents the group from l_1 who reach the age of two years, and so on. Thus, l_x is defined as the number of individuals who survive to age x.

The number of individuals who die before reaching the age of $x + 1$ is denoted by d_x (Larson, 1951):

$$d_x = l_x - l_{x+1} \tag{7}$$

The probability of an individual aged x dying before reaching age $x + 1$ is represented by q_x (Larson, 1951):

$$q_x = \frac{l_x - l_{x+1}}{l_x} = \frac{d_x}{l_x} \tag{8}$$

The probability of an individual aged x surviving to age $x + 1$ is represented by p_x (Larson, 1951):

$$p_x = \frac{l_{x+1}}{l_x} \tag{9}$$

The probability of an individual aged x surviving to age $x + t$ is represented by ${}_tp_x$ (Larson, 1951):

$$ {}_tp_x = \frac{l_{x+t}}{l_x} \tag{10}$$

The probability of an individual aged xxx dying before reaching age $x + t$ is represented by ${}_tq_x$ (Larson, 1951):

$$ {}_tq_x = \frac{l_x - l_{x+t}}{l_x} \tag{11}$$

The probability of an individual aged x surviving to the end of year t and dying in year $t + 1$ is represented by ${}_{t|}q_x$ (Larson, 1951):

$$ {}_{t|}q_x = \frac{d_{x+t}}{l_x} \tag{12}$$

According to Larson (1951), to facilitate the calculation of premium reserves, premiums, annuities, and other calculations, commutation symbols are used. These symbols simplify calculations involving the mortality table. The commutation symbols are as follows:

$$D_x = v^x . l_x \tag{13}$$

D_x represents the commutation symbol derived from multiplying the number of individuals alive at age x by the present value factor (v) raised to the power of age x.

$$N_x = \sum_{k=0}^{w} D_{x+k} = D_x + D_{x+1} + \cdots + D_w \tag{14}$$

N_x is the commutation symbol representing the sum of $D_x + k$ for $k = 0$ years to w.

$$C_x = v^{x+1} d_x \tag{15}$$

C_x is the commutation symbol derived from multiplying the number of individuals who died at age x by the present value factor (v) raised to the power of age $x + 1$.

$$M_x = \sum_{k=0}^{w} C_{x+k} = C_x + C_{x+1} + \cdots + C_w \tag{16}$$

M_x is the commutation symbol representing the sum of C_{x+k} for $k = 0$ years to w, where w is the maximum age in the mortality table.

2.4 . Life Annuities

According to Alpman and Unal (2019), a series of payments made at certain intervals is called an annuity. A contract to protect the financial well-being of an individual in the event of death is referred to as a life insurance agreement. Life insurance policies require a contract between the insurer and the insured.

Based on its type, annuities are divided into two categories: certain annuities and life annuities. A certain annuity is an annuity guaranteed to be paid over a specific payment period. In other words, payments from a certain annuity are made periodically over a certain time frame. On the other hand, payments that depend on the survival or death of an individual are called life annuities. A life annuity is an annuity accompanied by a survival factor, meaning it always considers age as a factor. The survival factor in actuarial science is essential, particularly in life insurance, because the benefits and compensations provided are related to an individual's age (the probability of living or dying).

The end-of-life annuity for an individual aged x years with an annual payment of 1 unit is given by Larson (1951) as follows:

$$a_x = \sum_{t=1}^{w} v^t . \, {}_t p_x \tag{17}$$

Substituting equation (10) into equation (17), we obtain:

$$a_x = \sum_{t=1}^{w} v^t . \frac{l_{x+t}}{l_x}$$
$$= \frac{v \cdot l_{x+1} + v^2 \cdot l_{x+2} + \cdots + v^w \cdot l_{x+w}}{l_x}$$
$$= \frac{v^x}{v^x} \times \frac{v \cdot l_{x+1} + v^2 \cdot l_{x+2} + \cdots + v^w \cdot l_{x+w}}{l_x}$$

Based on equation (13), it is derived that:

$$a_x = \frac{D_{x+1} + D_{x+2} + \cdots + D_w}{D_x}$$

Using equation (14), the equation for a_x can be rewritten as:

$$a_x = \frac{N_{x+1}}{D_x} \tag{18}$$

The present value of an initial life annuity for whole life insurance at age x with an annual payment of 1 unit, denoted as $\ddot{a}_x$, is formulated as follows (Larson, 1951).

$$\ddot{a}_x = \sum_{t=0}^{w} v^t \cdot {}_t p_x \tag{19}$$

Substituting equation (10) into equation (19):

$$\ddot{a}_x = \sum_{t=0}^{w} v^t . \frac{l_{x+t}}{l_x}$$

$$= \frac{l_x + v \cdot l_{x+1} + v^2 \cdot l_{x+2} + \cdots + v^w \cdot l_{x+w}}{l_x}$$

$$= \frac{v^x}{v^x} \times \frac{l_x + v \cdot l_{x+1} + v^2 \cdot l_{x+2} + \cdots + v^w \cdot l_{x+w}}{l_x}$$

Based on equation (13), it is derived that:

$$\ddot{a}_x = \frac{D_x + D_{x+1} + D_{x+2} + \cdots + D_w}{D_x}$$

Using equation (14), the equation for $\ddot{a}_x$ can be rewritten as:

$$\ddot{a}_x = \frac{N_x}{D_x} \tag{20}$$

2.5 . Premium Reserve

Premium reserve represents the amount of money held by an insurance company during the coverage period. Typically, costs are higher at the start of the year due to administrative expenses, which may lead the company to incur losses. To avoid such losses, the calculation of premium reserves can be modified, which is known as modified reserve.

Reserves in life insurance represent the insurance company's liability to policyholders, expressed as a certain amount of funds that the company must allocate to pay for claims arising from policies issued by the company.

According to Fajriani, Djuwandi, and Wilandari (2013), premium reserve calculations are performed using the following methods:

- **Prospective Reserve**
  The prospective reserve is a calculation of reserves based on the present value of all future expenditures minus the present value of all future income for each policyholder.
- **Retrospective Reserve**
  The retrospective reserve is a calculation of reserves based on the total income received in the past up to the time of reserve calculation, minus the total expenditures incurred in the past.

In this study, the prospective reserve method is used. The size of the prospective reserve at year-t (${}_tV$) is the reserve value based on the present value of future benefits minus the present value of future premiums. The formula for the prospective reserve is as follows (Larson, 1951):

$${}_tV = A_{x+t} - P_x \ddot{a}_{x+t} \tag{21}$$

where:

x = Age of the policyholder at the time of insurance enrollment
A_{x+t} = Present value of a single net premium at age $x + t$
$\ddot{a}_{x+t}$ = Present value of an initial annuity at age $x + t$
P_x = Annual net premium at age x

2.6 . New Jersey Method

The New Jersey method was developed as an improvement over the Illinois method. The reserve determination using the New Jersey method produces more effective values for insurance policies with premium payments exceeding 20 times.

The New Jersey method is part of prospective reserve calculations. The value of the prospective reserve at year t represents the reserve value based on the present value of future benefits minus the present value of future premiums.

The New Jersey method states that the reserve at the end of the first year is zero. Thus, mathematically, the premium value for the first year can be expressed as:

$$\alpha^J = \frac{C_x}{D_x} \tag{22}$$

Therefore, β^J can be derived as:

$$\begin{aligned}\beta^J &= \frac{M_{x+1}}{N_{x+1}} \\ &= P_{x+1}\end{aligned} \tag{23}$$

The adjusted continuation net premium (β^J) in the New Jersey method for whole life insurance is the annual net premium issued for a person one year older (x + 1).

The New Jersey method states that if the reserve at the end of the first year is zero, then ${}_tV^J = 0$. According to Larson (1951), the reserve value for the end of the second year and beyond is obtained by applying the Fackler method, which is expressed as:

$${}_tV = u_{x+t-1}({}_{t-1}V + P) - k_{x+t-1}$$

where

$$u = \frac{D_{x+t-1}}{D_{x+t}}, k = \frac{C_{x+t-1}}{D_{x+t}}$$

Thus, the reserve value using the New Jersey method, with the annual net premium applied at age $x+1$ and benefits (S) of Rp 1,00, is derived from the prospective reserve formula using the New Jersey method as follows:

$$\begin{aligned}{}_tV^J &= \frac{D_{x+t-1}}{D_{x+t}}({}_{t-1}V + P_{x+1}) - \frac{C_{x+t-1}}{D_{x+t}} \\ &= \frac{D_{x+t-1}}{D_{x+t}}\left(\frac{M_{x+t-1}}{D_{x+t-1}} - P_{x+1}\frac{N_{x+t-1}}{D_{x+t-1}} + P_{x+1}\right) - \frac{C_{x+t-1}}{D_{x+t}} \\ &= \frac{M_{x+t-1}}{D_{x+t}} - P_{x+1}\frac{N_{x+t-1}}{D_{x+t-1}} + P_{x+1}\frac{D_{x+t-1}}{D_{x+t}} - \frac{C_{x+t-1}}{D_{x+t}} \\ &= \frac{M_{x+t-1} - C_{x+t-1}}{D_{x+t}} - P_{x+1}\frac{N_{x+t-1} - D_{x+t-1}}{D_{x+t}} \\ &= \frac{M_{x+t}}{D_{x+t}} - P_{x+1}\frac{N_{x+t}}{D_{x+t}} \\ &= A_{x+t} - P_{x+1}\ddot{a}_{x+t} \\ &= A_{x+t} - \beta^J\ddot{a}_{x+t}\end{aligned} \tag{24}$$

Based on Equation (24), it can be concluded that the reserve value using the New Jersey method for whole life insurance, in general, is:

$${}_tV^J = S(A_{x+t} - \beta^J\ddot{a}_{x+t}) \tag{25}$$

Where:

${}_tV^J$ = Reserve value at the end of year-t using the New Jersey method

S = Benefit value

A_{x+t} = Single net premium for whole life insurance at age x + t

β^J = Adjusted continuation net premium using the New Jersey method

3. Materials and Methods

3.1. Materials

The data used in this study is secondary data in the form of the Indonesian Mortality Table (TMI) 2011 obtained from the Indonesian Actuarial Association (PAI). In this study, several age groups with 5-year intervals were used, namely ages 25, 30, 35, 40, and 45 years, aiming to analyze the relationship between the age of insurance participants and the amount of premium reserves. The researcher selected this minimum and maximum age range because younger individuals tend to have better health levels compared to older age groups, which impacts the premium amount.

The study uses a benefit amount of Rp 100.000.000 and an interest rate corresponding to the prevailing interest rate in Indonesia, sourced from the Central Bank of Indonesia's reference rate, which is 6.00%, as obtained from the official Bank Indonesia website on November 20, 2024 (www.bi.go.id).

Table 1*:* Indonesian Mortality Table 2011 (Male)

x	q_x (male)	$p_x = 1 - q_x$	l_x
25	0.00085	0.99915	98177.3191
26	0.00083	0.99917	98093.8684
27	0.00079	0.99921	98012.4505
28	0.00075	0.99925	97935.0206
29	0.00074	0.99926	97861.5694
30	0.00076	0.99924	97789.1518
31	0.0008	0.9992	97714.8321
32	0.00083	0.99917	97636.6602
33	0.00084	0.99916	97555.6218
34	0.00086	0.99914	97473.675
35	0.00091	0.99909	97389.8477
36	0.00099	0.99901	97301.2229
37	0.00109	0.99891	97204.8947
38	0.0012	0.9988	97098.9414
39	0.00135	0.99865	96982.4226
40	0.00153	0.99847	96851.4964
41	0.00175	0.99825	96703.3136
42	0.00196	0.99804	96534.0828
43	0.00219	0.99781	96344.876
44	0.00246	0.99754	96133.8807
45	0.00279	0.99721	95897.3914
46	0.00318	0.99682	95629.8376
47	0.00363	0.99637	95325.7348
48	0.00414	0.99586	94979.7023
49	0.00471	0.99529	94586.4864
50	0.00538	0.99462	94140.984
51	0.00615	0.99385	93634.5055
52	0.00699	0.99301	93058.6533
53	0.00784	0.99216	92408.1733
54	0.00872	0.99128	91683.6932
55	0.00961	0.99039	90884.2114
56	0.01051	0.98949	90010.8142
57	0.01142	0.98858	89064.8005
58	0.01232	0.98768	88047.6805
59	0.01322	0.98678	86962.9331
60	0.01417	0.98583	85813.2831
61	0.01521	0.98479	84597.3089
62	0.01639	0.98361	83310.5838
63	0.01773	0.98227	81945.1233
64	0.01926	0.98074	80492.2363
65	0.021	0.979	78941.9558
66	0.02288	0.97712	77284.1748
67	0.02486	0.97514	75515.9128
68	0.02702	0.97298	73638.5872
69	0.02921	0.97079	71648.8726
70	0.03182	0.96818	69556.009

71	0.03473	0.96527	67342.7368
72	0.03861	0.96139	65003.9236
73	0.04264	0.95736	62494.1221
74	0.04687	0.95313	59829.3727
75	0.05155	0.94845	57025.17
76	0.05664	0.94336	54085.5225
77	0.06254	0.93746	51022.1185
78	0.06942	0.93058	47831.1952
79	0.07734	0.92266	44510.7537
80	0.08597	0.91403	41068.292
81	0.09577	0.90423	37537.6509
82	0.10593	0.89407	33942.6701
83	0.11683	0.88317	30347.123
84	0.12888	0.87112	26801.6687
85	0.14241	0.85759	23347.4696
86	0.15738	0.84262	20022.5565
87	0.17363	0.82637	16871.4065
88	0.1911	0.8089	13942.0242
89	0.20945	0.79055	11277.7034
90	0.22853	0.77147	8915.58841
91	0.24638	0.75362	6878.10899
92	0.26496	0.73504	5183.4805
93	0.2845	0.7155	3810.0655
94	0.30511	0.69489	2726.10187
95	0.32682	0.67318	1894.34093
96	0.34662	0.65338	1275.23243
97	0.3677	0.6323	833.211362
98	0.39016	0.60984	526.839544
99	0.41413	0.58587	321.287828
100	0.43974	0.56026	188.2329

3.2. Methods

3.2.1 Determining the Value of a Lifetime Annuity

Before calculating the value of a lifetime annuity, commutation symbols are needed to simplify the calculation. Commutation symbols are closely related to the mortality table and are used to calculate premiums, annuities, reserve premiums, and other calculations. These symbols include D_x, C_x, N_x, and M_x.

a. Calculating D_x
   To find the value of D_x equation (13) is used:

$$D_x = v^x.\ l_x$$

- For $x = 25$ years

$$D_{25} = v^{25}.\ l_{25}$$
$$= \left(\frac{1}{1+i}\right)^{25} \times 98177.319$$
$$= \left(\frac{1}{1+0.06}\right)^{25} \times 98177.319$$
$$= 22875.18$$

Thus, $D_{25} = 22875.18$, which represents the present value of the survival of a person aged 25 years.

- For $x = 30$ years

$$D_{30} = v^{30}.\ l_{30}$$

$$= \left(\frac{1}{1+i}\right)^{30} \times 97789.151$$
$$= \left(\frac{1}{1+0.06}\right)^{30} \times 97789.151$$
$$= 17026.081$$

Thus, $D_{30} = 17026.081$, which represents the present value of the survival of a person aged 30 years.

- For $x = 35$ years

$$D_{35} = v^{35}.\ l_{35}$$
$$= \left(\frac{1}{1+i}\right)^{35} \times 97389.847$$
$$= \left(\frac{1}{1+0.06}\right)^{35} \times 97389.847$$
$$= 12670.927$$

Thus, $D_{35} = 12670.927$, which represents the present value of the survival of a person aged 35 years.

- For $x = 40$ years

$$D_{40} = v^{40}.\ l_{40}$$
$$= \left(\frac{1}{1+i}\right)^{40} \times 96851.496$$
$$= \left(\frac{1}{1+0.06}\right)^{40} \times 96851.496$$
$$= 9416.114$$

Thus, $D_{40} = 9416.114$, which represents the present value of the survival of a person aged 40 years.

- For $x = 45$ years

$$D_{45} = v^{45}.\ l_{45}$$
$$= \left(\frac{1}{1+i}\right)^{45} \times 96851.496$$
$$= \left(\frac{1}{1+0.06}\right)^{45} \times 95897.391$$
$$= 6966.952$$

Thus, $D_{45} = 6966.952$, which represents the present value of the survival of a person aged 45 years.

b. Calculating C_x
To calculate C_x, equation (15) is used:

$$C_x = v^{x+1} d_x$$

where $d_x = l_x - l_{x+1}$

- For $x = 25$ years

$$C_{25} = v^{25+1}\, d_{25}$$
$$= v^{26}\, d_{25}$$
$$= \left(\frac{1}{1+i}\right)^{26} \times (l_{25} - l_{26})$$
$$= \left(\frac{1}{1+0,06}\right)^{26} \times (98177.319 - 98093.868)$$
$$= 18.343$$

Thus, $C_{25} = 18.343$ indicating the cash value of payments for age 25 with the number of insurance participants who died at age 25.

- For $x = 30$ years

$$\begin{aligned} C_{30} &= v^{30+1}\, d_{30} \\ &= v^{31}\, d_{30} \\ &= \left(\frac{1}{1+i}\right)^{31} \times (l_{30} - l_{31}) \\ &= \left(\frac{1}{1+0{,}06}\right)^{31} \times (97789.151 - 97714.832) \\ &= 12.207 \end{aligned}$$

Jadi, diperoleh nilai $C_{30} = 12.207$ menunjukkan nilai tunai pembayaran usia 30 years dengan jumlah anggota asuransi yang meninggal di usia 30 years.

- For x = 35 years

$$\begin{aligned} C_{35} &= v^{35+1}\, d_{35} \\ &= v^{36}\, d_{35} \\ &= \left(\frac{1}{1+i}\right)^{36} \times (l_{35} - l_{36}) \\ &= \left(\frac{1}{1+0.06}\right)^{36} \times (97389.847 - 97301.222) \\ &= 10.877 \end{aligned}$$

Thus, $C_{35} = 10.887$, indicating the cash value of payments for age 35 with the number of insurance participants who died at age 35.

- For $x = 40$ years

$$\begin{aligned} C_{40} &= v^{40+1}\, d_{40} \\ &= v^{41}\, d_{40} \\ &= \left(\frac{1}{1+i}\right)^{41} \times (l_{40} - l_{41}) \\ &= \left(\frac{1}{1+0.06}\right)^{41} \times (96851.496 - 96703.313) \\ &= 13.591 \end{aligned}$$

Thus, $C_{40} = 13.591$, indicating the cash value of payments for age 40 with the number of insurance participants who died at age 40.

- For $x = 45$ years

$$\begin{aligned} C_{45} &= v^{45+1}\, d_{45} \\ &= v^{46}\, d_{45} \\ &= \left(\frac{1}{1+i}\right)^{46} \times (l_{45} - l_{46}) \\ &= \left(\frac{1}{1+0.06}\right)^{46} \times (95897.391 - 95629.837) \\ &= 18.338 \end{aligned}$$

Thus, $C_{35} = 18.338$, indicating the cash value of payments for age 45 with the number of insurance participants who died at age 45.

c. Calculating N_x

To calculate the value of N_x, Equation (14) is used:

$$N_x = \sum_{k=0}^{w} D_{x+k} = D_x + D_{x+1} + \cdots + D_w$$

- For $x = 25$ to $w = 100$

$$N_{25} = D_{25} + D_{26} + D_{27} + \cdots + D_{100}$$

$$= 22875.181 + 21562.016 + 20324.641 + \cdots + 0.555$$
$$= 374793.831$$

Using Microsoft Excel for the calculation, the result is $N_{25} = 374793.831$, which represents the accumulated value of D_{x+k} from k = 0 years to w.

- For $x = 30$ to $w = 100$

$$N_{30} = D_{30} + D_{31} + D_{32} + \cdots + D_{100}$$
$$= 17026.082 + 16050.134 + 15129.523 \ldots + 0.555$$
$$= 272811.938$$

Using Microsoft Excel, the result is $N_{30} = 272811.938$, which represents the accumulated value of D_{x+k} with k = 0 years to w.

- For $x = 35$ to $w = 100$

$$N_{35} = D_{35} + D_{36} + D_{37} + \cdots + D_{100}$$
$$= 12670{,}927 + 11942{,}827 + 11255{,}664 + \cdots + 0{,}555$$
$$= 196902{,}168$$

Using Microsoft Excel, the result is $N_{35} = 196902{,}168$, which represents the accumulated value of D_{x+k} with k = 0 years to w.

- For $x = 40$ to $w = 100$

$$N_{40} = D_{40} + D_{41} + D_{42} + \cdots + D_{100}$$
$$= 9416.114 + 8869.536 + 8352.843 + \cdots + 0.555$$
$$= 140431.199$$

Using Microsoft Excel, the result is $N_{40} = 140431.199$, which represents the accumulated value of D_{x+k} with k = 0 years to w.

- For $x = 45$ to $w = 100$

$$N_{45} = D_{45} + D_{46} + D_{47} + \cdots + D_{100}$$
$$= 6966.953 + 6554.259 + 6163.601 + \cdots + 0.555$$
$$= 98524.928$$

Using Microsoft Excel, the result is $N_{45} = 98524.928$, which represents the accumulated value of D_{x+k} with k = 0 years to w.

d. Calculating M_x

To calculate M_x, equation (16) is used:

$$M_x = \sum_{k=0}^{w} C_{x+k} = C_x + C_{x+1} + \cdots + C_w$$

- For $x = 25$ and $w = 100$

$$M_{25} = C_{25} + C_{26} + C_{27} + \cdots + C_{100}$$
$$= 18.343 + 16.883 + 15.148 + \cdots + 0.2301$$
$$= 1660.143$$

Using Microsoft Excel, the result is $M_{25} = 1660.143$, which represents the accumulated value of C_{x+k} with k = 0 years to w.

- For $x = 30$ and $w = 100$

$$M_{30} = C_{30} + C_{31} + C_{32} + \cdots + C_{100}$$
$$= 12.207 + 12.113 + 11.847 + \cdots + 0.2301$$
$$= 1583.604$$

Using Microsoft Excel, the result is $M_{30} = 1583.604$, which represents the accumulated value of C_{x+k} with k = 0 years to w.

- For $x = 35$ and $w = 100$

$$\begin{aligned} M_{35} &= C_{35} + C_{36} + C_{37} + \cdots + C_{100} \\ &= 10.878 + 11.154 + 11.574 + \cdots + 0.2301 \\ &= 1525.228 \end{aligned}$$

Using Microsoft Excel, the result is $M_{35} = 1525.228$, which represents the accumulated value of C_{x+k} with k = 0 years to w.

- For $x = 40$ and $w = 100$

$$\begin{aligned} M_{40} &= C_{40} + C_{41} + C_{42} + \cdots + C_{100} \\ &= 13.591 + 14.643 + 15.445 + \cdots + 0.2301 \\ &= 1466.885 \end{aligned}$$

Using Microsoft Excel, the result is $M_{40} = 1466.885$, which represents the accumulated value of C_{x+k} with k = 0 years to w.

- For $x = 45$ and $w = 100$

$$\begin{aligned} M_{45} &= C_{45} + C_{46} + C_{47} + \cdots + C_{100} \\ &= 18.338 + 19.663 + 21.107 + \cdots + 0.2301 \\ &= 1389.777 \end{aligned}$$

Using Microsoft Excel, the result is $M_{45} = 1389.777$, which represents the accumulated value of C_{x+k} with k = 0 years to w.

e. Calculating the Value of Lifetime Annuity

To calculate the lifetime annuity, use Equation (20):

$$\ddot{a}_x = \frac{N_x}{D_x}$$

- For x = 25 years

$$\ddot{a}_x = \frac{N_{25}}{D_{25}} = \frac{374739.831}{1660.143} = 225.76$$

- For x = 30 years

$$\ddot{a}_x = \frac{N_{30}}{D_{30}} = \frac{272811.938}{1583.604} = 172.273$$

- For x = 35 years

$$\ddot{a}_x = \frac{N_{35}}{D_{35}} = \frac{196902.168}{1525.228} = 129.097$$

- For x = 40 years

$$\ddot{a}_x = \frac{N_{40}}{D_{40}} = \frac{140431.199}{1466.885} 95.734$$

- For x = 45 years

$$\ddot{a}_x = \frac{N_{45}}{D_{45}} = \frac{98524.928}{1389.777} = 70.893$$

3.2.2 Calculating the Single Net Premium for Lifetime Insurance

The formula for the single net premium of lifetime insurance is as follows:

$$A_x = \frac{M_x}{D_x}$$

- For x = 25 years

$$A_{25} = \frac{M_{25}}{D_{25}} = \frac{1660.143}{22875.181} = 0.072574$$

- For x = 30 years

$$A_{30} = \frac{M_{30}}{D_{30}} = \frac{1583.604}{17026.082} = 0.09301$$

- For x = 35 years

$$A_{35} = \frac{M_{35}}{D_{35}} = \frac{1525.228}{12670.927} = 0.120372$$

- For x = 40 years

$$A_{40} = \frac{M_{40}}{D_{40}} = \frac{1466.885}{9416.114} = 0.155785$$

- For x = 45 years

$$A_{45} = \frac{M_{45}}{D_{45}} = \frac{1389.777}{98524.928} = 0.199481$$

The single net premiums for lifetime insurance with a benefit of Rp 100.000.000 for participants aged 25, 30, 35, 40, and 45 years are as follows:

Table 2: Single Net Premium for Whole Life Insurance

x	Besar Santunan	A_x	Premi Bersih Tunggal
25	IDR 100,000,000	0.072574	IDR 7,257,396
30	IDR 100,000,000	0.09301	IDR 9,301,045
35	IDR 100,000,000	0.120372	IDR 12,037,228
40	IDR 100,000,000	0.155785	IDR 15,578,457
45	IDR 100,000,000	0.199481	IDR 19,948,128

3.2.3 Calculating the Annual Net Premium for Lifetime Insurance

The formula for the annual net premium of lifetime insurance is as follows:

$$P_x = \frac{A_x}{\ddot{a}_x}$$

- For x = 25 years

$$P_{25} = \frac{A_{25}}{\ddot{a}_{25}} = \frac{0.072574}{225.76} = 0.000321$$

- For x = 30 years

$$P_{30} = \frac{A_{30}}{\ddot{a}_{30}} = \frac{0.09301}{172.273} = 0.00054$$

- For x = 35 years

$$P_{35} = \frac{A_{35}}{\ddot{a}_{35}} = \frac{0.120372}{129.097} = 0.000932$$

- For x = 40 years

$$P_{40} = \frac{A_{40}}{\ddot{a}_{40}} = \frac{0.155785}{95.734} = 0.001627$$

- For x = 45 years

$$P_{45} = \frac{A_{45}}{\ddot{a}_{45}} = \frac{0.199481}{70.893} = 0.002814$$

The annual net premiums for lifetime insurance with a benefit of Rp 100.000.000 for participants aged 25, 30, 35, 40, and 45 years are as follows:

Table 3: Annual Net Premium for Whole Life Insurance

x	Besar Santunan	P_x	Premi Bersih Yearsan
25	IDR 100,000,000	0.000321	IDR 32.146
30	IDR 100,000,000	0.00054	IDR 53.990
35	IDR 100,000,000	0.000932	IDR 93.241
40	IDR 100,000,000	0.001627	IDR 162.726
45	IDR 100,000,000	0.002814	IDR 281.385

3.2.4 Calculating the Renewal Net Premium for Lifetime Insurance

The renewal net premium for lifetime insurance β^J is calculated as follows:

$$\beta^J = P_{x+1}$$

- For x = 25 years

$$\beta^J = P_{26} = 0.000355229$$

- For x = 30 years

$$\beta^J = P_{31} = 0.000601473$$

- For x = 35 years

$$\beta^J = P_{36} = 0.001042275$$

- For x = 40 years

$$\beta^J = P_{41} = 0.001817544$$

- For x = 45 years

$$\beta^J = P_{46} = 0.003134247$$

The renewal net premiums for lifetime insurance with a benefit of IDR 100,000,000 for participants aged 25, 30, 35, 40, and 45 years are as follows:

Table 4: Renewal Net Premium for Whole Life Insurance

x	Besar Santunan	β^J	Premi Bersih Yearsan
25	IDR 100,000,000	0.000355229	IDR 35,522
30	IDR 100,000,000	0.000601473	IDR 60,147
35	IDR 100,000,000	0.001042275	IDR 104,227
40	IDR 100,000,000	0.001817544	IDR 181,754
45	IDR 100,000,000	0.003134247	IDR 313,424

3.2.5 Calculating Reserve Values Using the New Jersey Method

The reserve value formula using the New Jersey method is denoted as ${}_tV^J$ and is as follows:

$${}_tV^J = S(A_{x+t} - \beta^J \ddot{a}_{x+t})$$

- For age 25 years

  The reserve value for the New Jersey method at x = 25 years and t = 1

$$\begin{aligned}{}_1V^J &= S(A_{25+1} - \beta^J \ddot{a}_{25+1}) \\ &= 100{,}000{,}000(0.076143123 - (0.000355229 \times 214.349) \\ &= 0\end{aligned}$$

  Thus, the reserve value at the end of the first year for whole life insurance using the New Jersey method is zero. The reserve value for the New Jersey method at x = 25 years and t = 2

$$\begin{aligned}{}_2V^J &= S(A_{25+2} - \beta^J \ddot{a}_{25+2}) \\ &= 100{,}000{,}000(0.079948068 - (0.000355229 \times 203.307) \\ &= 772{,}752\end{aligned}$$

  Thus, the reserve value at the end of the second year for whole life insurance using the New Jersey method is Rp 772.752. The reserve value for the New Jersey method at x = 25 years and t = 3

$$
\begin{aligned}
{}_3V^J &= S(A_{25+3} - \beta^J \ddot{a}_{25+3}) \\
&= 100{,}000{,}000(0.084021329 - (0.000355229 \times 192.594) \\
&= \ 1{,}560{,}635
\end{aligned}
$$

Thus, the reserve value at the end of the third year for whole life insurance using the New Jersey method is Rp 1.560.635.

The calculations for reserve values at the end of the fourth year and subsequent years, as well as for ages 30, 35, 40, and 45, are performed using the same method described above. From these calculations, the reserve values for the New Jersey method for insurance participants aged 25, 30, 35, 40, and 45 years, for ttt from 1 to 20, with a sum assured of IDR 10,000,000, are summarized in Table 5 below.

Table 5: Reserve Values Using the New Jersey Method at the End of Year-t

t	x = 25		x = 30		x = 35		x = 40		x = 45	
1	IDR	0	IDR	0	IDR	0	IDR	0	IDR	0
2	IDR	772,754.41	IDR	1,058,732.98	IDR	1,409,015.22	IDR	1,792,028.00	IDR	2,222,522.14
3	IDR	1,560,628.12	IDR	2,120,386.14	IDR	2,810,442.70	IDR	3,564,163.72	IDR	4,397,930.76
4	IDR	2,364,657.51	IDR	3,191,193.16	IDR	4,207,829.34	IDR	5,320,706.55	IDR	6,528,479.97
5	IDR	3,181,412.86	IDR	4,272,400.53	IDR	5,600,311.45	IDR	7,063,082.19	IDR	8,616,756.77
6	IDR	4,008,266.82	IDR	5,362,663.48	IDR	6,989,078.86	IDR	8,790,380.53	IDR	10,660,197.57
7	IDR	4,844,672.17	IDR	6,461,255.91	IDR	8,374,277.55	IDR	10,502,346.02	IDR	12,657,008.43
8	IDR	5,694,552.69	IDR	7,569,260.34	IDR	9,762,837.35	IDR	12,199,200.01	IDR	14,609,538.03
9	IDR	6,563,044.98	IDR	8,689,267.67	IDR	11,157,608.15	IDR	13,881,505.93	IDR	16,527,009.44
10	IDR	7,451,333.76	IDR	9,820,298.53	IDR	12,559,165.16	IDR	15,550,070.35	IDR	18,415,703.18
11	IDR	8,358,393.38	IDR	10,962,928.78	IDR	13,966,112.96	IDR	17,201,522.48	IDR	20,283,662.79
12	IDR	9,283,575.18	IDR	12,116,812.49	IDR	15,377,465.23	IDR	18,832,971.24	IDR	22,138,516.09
13	IDR	10,227,665.51	IDR	13,287,278.72	IDR	16,792,548.63	IDR	20,444,869.86	IDR	23,987,619.59
14	IDR	11,192,721.19	IDR	14,476,353.20	IDR	18,210,931.13	IDR	22,043,500.05	IDR	25,840,048.43
15	IDR	12,177,698.27	IDR	15,684,127.59	IDR	19,632,370.98	IDR	23,632,948.47	IDR	27,703,825.95
16	IDR	13,182,829.59	IDR	16,908,930.50	IDR	21,053,022.13	IDR	25,218,996.99	IDR	29,582,721.12
17	IDR	14,207,494.46	IDR	18,149,360.14	IDR	22,469,347.51	IDR	26,807,304.53	IDR	31,477,631.20
18	IDR	15,256,127.68	IDR	19,404,234.43	IDR	23,880,684.29	IDR	28,403,504.43	IDR	33,386,176.80
19	IDR	16,330,294.59	IDR	20,672,555.37	IDR	25,291,582.34	IDR	30,014,920.09	IDR	35,305,387.69
20	IDR	17,429,816.73	IDR	21,953,485.15	IDR	26,704,836.61	IDR	31,648,170.07	IDR	37,231,093.77

4. Conclussion

The determination of premium reserves in whole life insurance using the New Jersey method is influenced by the initial age of the insured. In this study, the initial ages analyzed are 25, 30, 35, 40, and 45 years, with a fixed interest rate of 6.00% and using the Indonesian Mortality Table (TMI) 2011. The results show that the older the initial age of the insured, the higher the premium reserve value obtained by the insurance company. This is due to the higher mortality rates at older ages compared to younger ages.

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