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Analysis of Premium Reserves in Whole Life and Term Life Insurance Using the New Jersey Prospective Method

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Abstract
Human life is constantly exposed to risks such as illness, accidents, and death, which create financial uncertainties for individuals and families. Life insurance serves as an essential financial instrument to mitigate these risks by transferring potential liabilities to insurance companies. This study analyzes premium reserves for whole life and term life insurance using the New Jersey Prospective Method, applying a 6% interest rate and the 2023 Indonesian Mortality Table (TMPI) as the basis of calculation. Actuarial commutation functions are employed to compute annuity values, single net premiums, annual net premiums, and reserve allocations across different ages. The results indicate that reserve values increase with age, reflecting higher mortality risks, with whole life insurance showing a sharper escalation compared to term life insurance. The New Jersey Prospective Method demonstrates accuracy and consistency in reserve estimation, particularly by setting zero reserves in the first policy year, thereby supporting initial liquidity. These findings highlight the method's effectiveness in maintaining financial stability and readiness of insurance companies to meet future claims and long-term obligations to policyholders.

Keywords: *New jersey method, premium reserve, term life insurance, whole life insurance.*

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1. INTRODUCTION

Human life is inherently exposed to risks such as illness, accidents, financial loss, and death, which are unpredictable and difficult to foresee. One way to mitigate these risks is through participation in term life insurance programs [1]. To address these uncertainties, insurance serves as a structured mechanism for transferring risk, where the policyholder shifts potential financial liabilities to the insurer [2]. Three main categories of life insurance exist: whole life, endowment, and term life insurance [1].

Whole life insurance provides lifelong protection, offering a predetermined benefit to beneficiaries upon the death of the insured, while also allowing policyholders to accumulate cash value from paid premiums [3]. In contrast, term life insurance covers individuals for a fixed duration, providing financial protection only during the specified policy term [4]. These different forms of coverage illustrate how life insurance policies are designed to meet essential family needs such as education, debt repayment, and daily expenses, thereby preventing financial hardship [5], [6].

Premiums, the payments made by policyholders to insurers, can be classified into net and gross premiums. Net premiums are calculated without considering additional costs, while gross premiums include expenses such as mortality, interest, and operational costs [7], [8]. Insurance companies must also maintain premium reserves, which represent liabilities to meet future claims. Reserve calculations can be performed using retrospective or prospective methods [9]. Classical actuarial literature has long emphasized the importance of reserve estimation, including the principle of equivalence between premiums and benefits [10], the development of non-Markov reserve models [11], and retrospective analysis methods that link past experience to prospective reserve adjustments [12].

Building on this theoretical foundation, scholars in recent years have sought to refine reserve calculation methods. Zulfadri, Arnellis, and Subhan (2019) [13] adapted the New Jersey Prospective Method for joint life insurance, showing its flexibility in handling complex policy structures. Sulistyawati and Kartikasari (2024) [14] examined the method under stochastic and constant interest rates, highlighting its resilience in diverse economic environments. In the same year, Hasriati et al. (2024) [15] compared prospective reserves with the full preliminary term reserve using a Clayton copula, reinforcing the importance of method choice in actuarial modeling. Most recently, Farida (2025) [16] applied the method to whole life insurance in Indonesia, confirming its accuracy in long-term reserve projections and validating its practical relevance.

The New Jersey method considers various economic and actuarial factors that affect the formation of reserves, so that it can produce more representative estimates, especially in the context of long-term premium payment schemes. The application of this method provides benefits to insurance companies in the form of increased accuracy and predictability in reserve calculations, which in turn supports financial stability and operational sustainability, especially in the midst of uncertain market dynamics [17]. In practice, life insurance companies often experience liquidity challenges in the first year of the policy, due to funding requirements for policy issuance, insured health checks, agent commission payments, and other operational costs [18]. The New Jersey method provides an apt resolution here, as it clearly establishes that no reserves are held at the conclusion of the initial twelve months [19], this enables the efficient distribution of funds during the opening phase of the insurance policy period.

Unlike previous studies that focused on joint life or stochastic interest rates, the present study extends the application of the New Jersey Prospective Method to both whole life and term life insurance policies in Indonesia. Using the 2023 Indonesian Mortality Table (TMPI) [20], this study demonstrates how the method's treatment of zero reserves in the first policy year alleviates liquidity constraints while maintaining accuracy. This integration of actuarial commutation functions with financial considerations offers insights for sustainable insurance planning in dynamic market conditions.

2. RESEARCH METHODS

2.1. Types of research

This research follows a quantitative approach, involving the use of numbers such as for data collection, processing, and result interpretation. It is a form of applied research, aimed at testing, applying, and evaluating effective problem-solving. The researcher refers to books, journals, and other related sources.

2.2. Compound Interest

The concept of compound interest is the main foundation in actuarial calculations. This principle is used to convert future payments into present value so that benefits and premiums can be compared fairly. The discount factor is written as:

$$\boldsymbol{v} = (\mathbf{1} + \boldsymbol{i})^{-\mathbf{1}}, \qquad \boldsymbol{v^t} = (\mathbf{1} + \boldsymbol{i})^{-\boldsymbol{t}}.$$

where $\boldsymbol{i}$ is the annual interest rate. This present value is the basis for calculating single premiums, annual premiums, death benefits, and premium reserves. Classical literature emphasizes that without the concept of the time value of money, actuarial calculations cannot be performed consistently [21].

2.3. Mortality Table

The mortality table is used to describe the probabilities of survival and death in a population. The basic elements used include:

- Number of individuals alive at age x (l_x),
- Number of individuals dying at age x (d_x);

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

- Probability of death (q_x);

$$q_x = \frac{d_x}{l_x},$$

- Probability of survival (p_x);

$$p_x = 1 - q_x.$$

The probability of survival for $t$years is written as ${}_tp_x$, while the probability of death in the t-th year is ${}_tq_x = {}_tp_x \cdot q_{x+t}$. The Indonesian Mortality Table (TMPI) 2023 [20] is used as the database in this study. Jordan [22] emphasizes that the mortality table is a fundamental instrument in all life insurance calculations.

2.4. Term Life and Whole Life Insurance

Term life insurance products provide protection for a limited period ($\boldsymbol{n}$ years), while whole life insurance provides protection without a time limit. The present value of death benefits is calculated as:

- Term life insurance;

$$\boldsymbol{A_{x:\overline{n}|}} = \sum_{t=0}^{n-1} \boldsymbol{v^{t+1}} \cdot {}_t\boldsymbol{p_{x_t}} \cdot \boldsymbol{q_{x+t}}.$$

- Whole life insurance;

$$A_x = \sum_{t=0}^{\infty} v^{t+1} \cdot {}_t p_{x_t} \cdot q_{x+t}.$$

This formulation provides an estimate of the present value of benefits to be paid by the insurance company to the beneficiaries. Neill **[23]** explains that the main difference between the two products lies in the coverage horizon.

2.5. Commutation Functions

Commutation functions are used to simplify the calculation of premiums and reserves. The definitions are:

$\boldsymbol{D_x = v^x l_x}$, $\boldsymbol{C_x = v^{x+1} d_x}$, $\boldsymbol{N_x = \sum_{k=x}^{\omega} D_k}$, $\boldsymbol{M_x = \sum_{k=x}^{\omega} C_k}$. [24]

2.6. Premium Calculation

Premiums are the price paid by participants to obtain insurance benefits.

- Single premium for whole life insurance;

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

- Single premium for term insurance;

$$\boldsymbol{A_{x:\overline{n}|} = \frac{M_x - M_{x+n}}{D_x}}.$$

- Annual premium;

$$\boldsymbol{P_x = \frac{A_x}{\ddot{a}_x}, \ \ddot{a}_x = \frac{N_x}{D_x}}. [25]$$

2.7. Premium Reserves

Premium reserves are the obligations of insurance companies to policyholders. The prospective formula defines reserves as the difference between the present value of future benefits and the present value of future premiums:

- Whole life insurance;

$$V_t = A_{x+t} - P_x \cdot \ddot{a}_{x+t}.$$

- Term life insurance;

$$V_t = A_{x+t:\overline{n-t}|} - P_x \cdot \ddot{a}_{x+t:\overline{n-t}|}.$$

Reserves ensure the solvency of the company and protection for policyholders.

2.8. New Jersey Prospective Method

The New Jersey method stipulates that reserves at the end of the first year are zero, $\boldsymbol{V_1 = 0}$. The first-year premium is used entirely for acquisition costs. From the second year onward, reserves are calculated using the standard prospective formula.

- Whole life insurance;

$$V_t^J = S \cdot A_{x+t} - \beta^j \cdot \ddot{a}_{x+t}.$$

- Term life insurance;

$$V_t^J = S \cdot A_{x+t:\overline{n-t}|} - \left(\beta^j - P_{x:n}\right) \cdot \ddot{a}_{x+t:\overline{n-t}|}.$$

This method combines present value principles with the special treatment of the first year, making it more realistic in addressing initial liquidity **[21]**, **[23]**.

2.9. Materials and Data

The analysis presented here is based on secondary data sourced from the 2023 Indonesian Mortality Table (TMPI), which pertains to the mortality rates of individuals aged x, with the underlying assumption that they are policyholders in either whole life or term life insurance policies in Indonesia [20]. The data includes age, gender, duration of coverage, sum assured, and an interest rate of 6% sourced from Bank Indonesia (BI).

3. RESULTS AND DISCUSSION

3.1 Premium Reserves in Whole Life and Term Life Insurance Using the New Jersey Prospective Method

For the purpose of this analysis, the researchers utilized information drawn from the 2023 Indonesian Mortality Table (TMPI) [20], focusing on the survival probabilities for policyholders aged 20, 25, 30, 35, 40, 45, and 50 years. The sum assured was IDR 50,000,000, and the duration of coverage used for term life insurance was 25 years. The interest rate applied was the rate set by Bank Indonesia (BI) at the time of the study, which was 6%. Determining the amount of premium reserves necessitates the use of a mortality table along with an established interest rate.

3.2 Commutation Value

These symbols are used in the calculation of premiums, annuities, premium reserves, and various other financial evaluations. Below are some relevant commutation symbols.

3.2.1 Determining the Value of D_x

To determine the value of D_x, which is the product of the present value of money (v) raised to the power of age (x) and the number of individuals still alive at age (x), denoted as lx, the following formula can be used:

$$D_x = v^x . l_x \tag{1}$$

$$= \left(\frac{1}{1+0.06}\right)^{20} (12.180.048{,}66)$$

$$= 3.797.796{,}74$$

results show that the value of $D_{20} = 3.797.796{,}746$.

3.2.2 Determining the Value of Cx

To ascertain the Cx value, derived from multiplying the discount factor (v) elevated to the power of (x+1) years of age and the quantity of insurance policyholders who passed away at age (x), it can be formulated as follows:

$$C_x = v^{x+1} . d_x \tag{2}$$

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

$$C_{20} = v^{21} . d_{20}$$

$$= \left(\frac{1}{1+0.06}\right)^{21} . (12.180.046{,}66 - 10.959.537{,}57)$$

$$= (0{,}294155403) . (10{,}012)$$

$$= 2.945{,}08$$

The calculation results show that the value of $C_{20} = 2.945{,}08$.

3.2.3 Determining the Value of N_x

To determine the value of N_x obtained by representing the total current value of all payments of Rp 1 made by an individual, starting from a certain age x until reaching the maximum age, we can use the formula:

$$N_x = D_{x+1} \dots + D_\omega \tag{3}$$

$$= D_{20} + D_{21} + D_{22} \dots + D_{111}$$

$$= 50.808.221{,}21$$

The calculation results show that the value of $N_{20} = 50.808.221{,}21$.

3.2.4 Determining the Value of M_x

To determine the value of M_x obtained by representing the total current value of all payments of Rp 1 made by an individual, starting from a certain age (x+1) until reaching the maximum age, we can use the formula:

$$M_x = C_x + C_{x+1} \dots + C_\omega \tag{4}$$

$$= C_{20} + C_{21} + C_{22} \dots + C_{111}$$

$$= 128.328{,}6$$

The calculation results show that the value of $M_{20} = 128.328{,}60$.

3.3 Determining the Value of an Annuity $\ddot{a}_x$ Lifetime and Term

After obtaining the value of the commutation symbol, Thus the lifetime annuity for a person aged $x = 20$ years can be explained as follows:

$$\ddot{a}_x = \frac{N_{20}}{D_{20}} \tag{5}$$

$$= \frac{50.808.221{,}21}{3.797.796{,}75}$$

$$= 13{,}38$$

So the value $\ddot{a}_{20}$= 13,38.

Simultaneously, determining the initial annuity value for a person who is x = 20 years old with a policy span of 25 years can be elucidated in the following manner:

$$\ddot{a}_{20:\overline{25|}} = \frac{N_{20} + N_{20+25}}{D_{20}} \tag{6}$$

$$= \frac{50.808.221{,}21 - 6.653.829{,}91}{3.797.796{,}75}$$

$$= 11{,}63$$

So the initial term annuity value with $\ddot{a}_{20:\overline{25|}} = 11{,}63$.

The results of the calculations for the lifetime and term annuity values for ages 25, 30, 35, 40, 45, and 50 are visually presented in **Figure 1**.

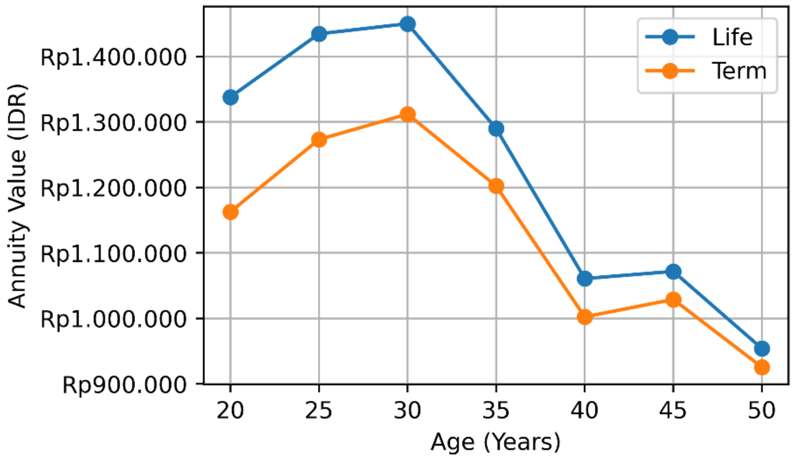

Figure 1. Value of life and term annuities

Figure 1 shows that the value of life and term annuities have similar trends, with both annuities increasing at a young age and peaking around age 30 before declining as age increases. A life annuity generally holds greater worth compared to a term annuity due to its provision of benefits that continue for the entire duration of the policyholder's life, whereas a term annuity confines these advantages to a specified timeframe.

3.4 Calculating the single net premium for whole and term life insurance

The calculation of life insurance premiums for age x = 20 can be determined as follows:

$$A_{20} = \frac{M_{20}}{D_{20}} \tag{7}$$

$$= \frac{128.328,6}{3.797.796,75}$$

$$= 0,034$$

So, value A_{20} = 0,034. Meanwhile, the calculation of the premium for term life insurance can be denoted by A_{x+n}, and is expressed using the following equation;

$$A_{20:\overline{25}|} = \frac{M_{20} + M_{20+25}}{D_{20}} \tag{8}$$

$$= \frac{128.328,61 - 67.588,21}{3.797.796,75}$$

$$= 0,016,$$

so, the resulting value $A_{20:\overline{25}|}$ = 0,016.

Figure 2 provides a visual representation of the premium costs associated with both whole life and term life insurance policies at the ages of 25, 30, 35, 40, 45, and 50.

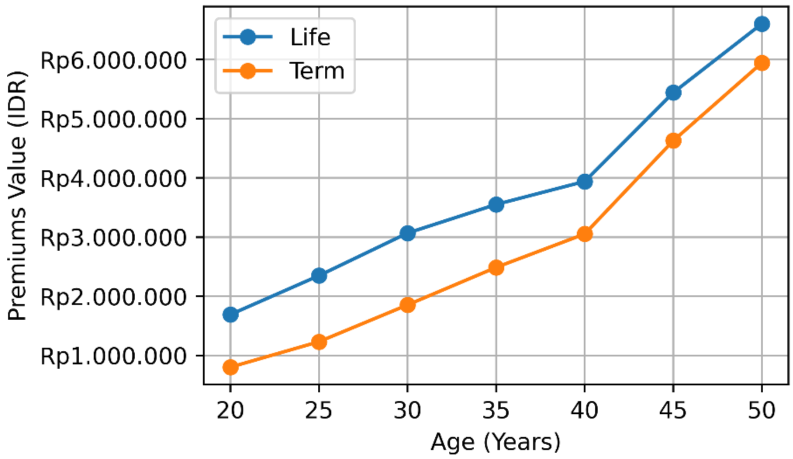

Figure 2. Premiums for whole life insurance and term (insurance)

The findings from the calculation indicate that premiums for whole life and term insurance exhibit a comparable growth trend relative to the age of the policyholder, as depicted in **Figure 2**. Throughout the insured's lifespan, it is observed that whole life insurance premiums consistently exceed those of term insurance, with both categories demonstrating an upward trajectory as age progresses. The increase in premiums occurs due to the increased risk of death, which causes insurance companies to allocate larger premium reserves to cover future liabilities. In addition, it can be seen that a sharper increase occurs at the age of over 40 years, indicating that risk factors are increasingly dominant in premium calculations.

3.5 Determining the annual net premium for whole and term life insurance

The total amount of premium paid for an entire life insurance policy, denoted as P_x, can be determined using the given formula: x = 20.

$$P_{20} = \frac{A_{20}}{\ddot{a}_{20}} \tag{9}$$

$$= \frac{0{,}034}{13{,}38}$$

$$= 0{,}0025$$

So the value P_{20}= 0.002525745.

The meantime, know life insurance can be denoted by $P^1{}_{x+\overline{n}|}$ using the following equation: x = 20.

$$P^1{}_{20:\overline{25}|} = \frac{A^1{}_{20+\overline{25}|}}{\ddot{a}_{20+\overline{25}|}} \tag{10}$$

$$= \frac{0{,}016}{11{,}63}$$

$$= 0{,}0014$$

So the value $\boldsymbol{P^1{}_{20:\overline{25}|}}$=$\mathbf{0,0014}$.

The annual pure premiums for whole life and term life insurance policies at ages 25, 30, 35, 40, 45, and 50 are shown in **Figure 3**.

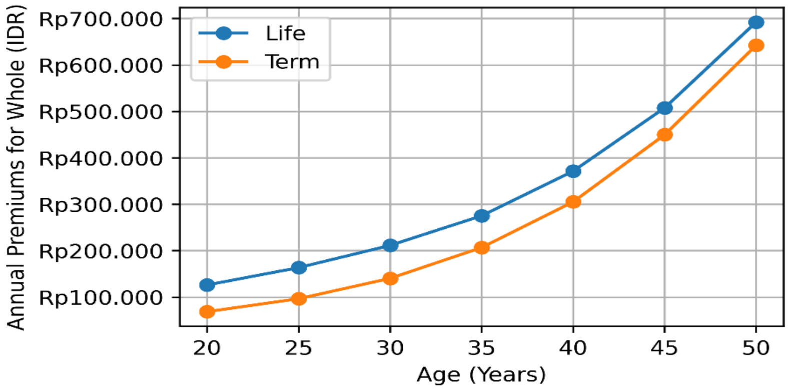

Figure 3. Annual pure premiums for whole life and term life insurance

Upon examining **Figure 3**, it becomes evident that the growth in annual net premiums for both whole life and term life insurance policies tends to ascend progressively with the age of the insured individual. This increase pattern is in line with the trends in **Figure 2** and **Figure 1**, which show that both insurance premiums and annuity values tend to increase or decrease according to the dynamics of age and actuar ial factors underlying the calculation of policy value. With the New Jersey. Prospective method , higher premiums in old age indicate that insurance companies need to allocate larger reserves to meet future benefit payment obligations.

3.6 Calculating the premium reserve value of whole life insurance using the New Jersey prospective method.

Determining the premium reserve value for whole life insurance via the New Jersey approach is symbolized by ${}_tV^j$ and uses the following equation: For age, t = 1.

$$\begin{aligned} {}_1V^j &= S(A_{20+1} - \beta^j \ddot{a}_{20+1}) \\ &= 50.000.000\ (A_{20+1} - \beta^j \ddot{a}_{20+1})) \\ &= 0 \end{aligned} \tag{10}$$

Thus, the accumulated worth resulting from the initial twelve months of a whole life insurance policy, when calculated with the New Jersey approach, amounts to Rp. 0. The results of the premium reserve calculation for $t > 1$can be seen in Figure 4.

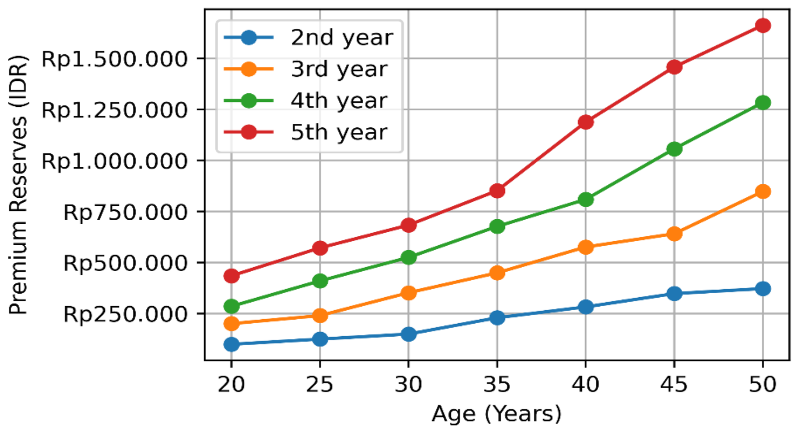

Figure 4. Premium reserves for whole life insurance

Calculation results in Figure 4 show that the premium reserves for whole life insurance gradually increase from the first year to the fifth year, with a pattern that becomes more significant as the insured's age advances. The New Jersey Prospective Method used ensures that the premium reserves develop in a structured manner, with a growing proportion of the premium allocated to the reserves as the years progress, thereby maintaining the financial stability of the insurance company and fulfilling long-term obligations to policyholders.

3.7 Calculating the premium reserve value of term life insurance using the New Jersey prospective method.

The calculation of the premium reserve value for term life insurance using the New Jersey method can be denoted by ${}_{t}V^{j}_{x:\overline{n|}}$ and uses the following equation:

For age 20 , t = 1

$$ {}_{t}V^{j}_{20:\overline{25|}} = SA^{1}_{20+1:\overline{25-1|}} - (\beta^{j} - P^{1}{}_{20:\overline{25|}})\, \ddot{a}^{1}_{20+1:\overline{25-1|}} \quad (11) $$

$$ = 50.000.000 \times 0{,}018 - (0{,}0015 - 0{,}0014)12{,}52 $$

$$ = 50.000.000\, A^{1}_{21:\overline{24|}} - (\beta^{j} - P^{1}{}_{20:\overline{25|}})\, \ddot{a}^{1}_{21:\overline{24|}} $$

$$ = 896.382{,}91 $$

Thus, the reserve value obtained at the end of the first year of term life insurance using the New Jersey method is Rp. 896.382,91.

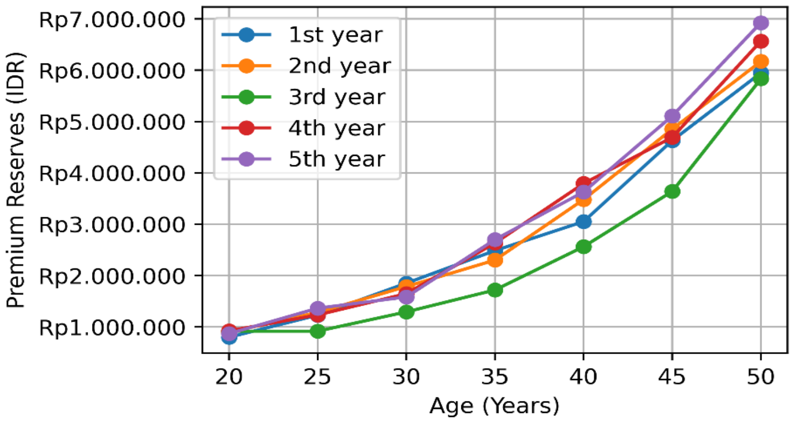

Figure 5. Premium reserves for term life insurance

Figure 5 shows that mark backup premium insurance soul futures increase along increase age participants, with more increase significant at age old. In the year first, value backup premium relatively low, but until year next happen improvement gradual which reflects need For anticipate risk claim more tall along increase age. This trend in accordance with principle actuarial that probability death increase along increase age, so that backup premium must customized for the company insurance still can fulfil his obligations [26].

4. CONCLUSION

The application of the New Jersey Prospective Method in calculating premium reserves for life insurance, both whole life and term policies, demonstrates that reserve values increase with the age of the insured, reflecting the heightened mortality risk at older ages. This approach provides a more systematic framework for insurance companies in managing financial obligations, thereby ensuring the availability of reserve funds to meet future claims. Furthermore, the method offers flexibility in periodic calculations, whether monthly or annually, which enhances the accuracy of financial planning for insurers. Thus, the implementation of the New Jersey Prospective Method not only strengthens the financial stability of insurance companies but also supports the sustainability of the insurance system in fulfilling long-term obligations to policyholders.

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