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Determination of Premium Reserves for Whole Life Insurance Using the Canadian Method with Varying Premium Payment Periods

Illuminata Wynnie[1*], Yefan[1]

[1]*Actuarial Science Study Program, Hasanuddin University, Perintis Kemerdekaan Street, 90245, Indonesia*
[*]*Corresponding Author: illuminataw@unhas.ac.id*

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Abstract

Premium reserves are essential funds prepared by insurance companies, particularly in life insurance, to cover potential future claims. These reserves are calculated based on premiums paid by policyholders and must be sufficient to meet all projected claim-related expenses. A lower reserve implies reduced financial liability and typically correlates with more affordable premium rates for policyholders. This study aims to analyze the determination of premium reserves using the Canadian and Prospective methods in traditional life insurance products, specifically whole life insurance, focusing on different premium payment periods. The Indonesian Population Mortality Table (TMPI) 2023 and the Bank Indonesia interest rate of 5.57% (as of April 2025) as the calculation basis. The results show that the Canadian method produces lower reserve values compared to the Prospective method and indicate a decreasing trend in reserve values as the premium payment period increases in both methods.

Keywords: Canadian Method, Premium Reserves, Prospective Method, Whole Life Insurances

1 Introduction

Insurance is a financial program designed to reduce risk through an agreement between two parties, in which one party pays a premium and the other party provides full coverage in the event of an incident as specified in the agreement [1]. One of the most commonly offered types of insurance in Indonesia is life insurance. In simple terms, life

insurance can be understood as a program that provides financial protection to an individual or their family in the event of life-related risks, such as death or permanent disability due to an accident [2]. Based on the duration of its coverage, life insurance can be classified into three types: term life insurance, whole life insurance, and endowment insurance [3].

A premium is a sum of money paid by the policyholder (insured) to the insurer as predetermined [4]. The company calculates the premium to be paid by the policyholder to obtain the agreed-upon benefits. However, sometimes the set premium is not sufficient to cover the company's expenses. Therefore, to cover this shortfall, the company must have a reserve fund called a premium reserve. A premium reserve is the money that must be set aside by the company to cover risks, which, in the case of endowment insurance, includes compensation to the insured or their beneficiary [5]. Premium reserves are usually based on the premiums received from policyholders and must cover all potential costs associated with future claim payments. A smaller premium reserve indicates that the insurance company estimates lower future liabilities. This can be due to factors such as a younger age of the insured or a shorter insurance period. As a result, the premiums offered to customers are also lower because the risks borne by the insurance company are smaller. Conversely, if the premium reserve is large, the company must allocate more funds to meet future claims, resulting in higher premiums charged to customers [6].

With technological advancements, actuaries have introduced many calculation methods to optimize premium reserves, such as the prospective, retrospective, Zillmer, New Jersey, and Canadian methods. The Canadian method is an extension of the prospective method, which equates the initial modified premium with the net premium and the difference between the policy’s net premium and natural premium. One advantage of this method is that it extends the modification period to cover the entire premium payment duration, thus reducing losses in the early years of premium reserve calculation [5].

Previous studies have examined various calculation methods to optimize premium reserves in whole life insurance. Sari [7] applied the Canadian method to calculate premium reserves for endowment life insurance and found that the reserve value obtained at the end of the coverage period matched the compensation value provided. Additionally,

Ekawati [5] showed that the Canadian method is very useful in creating joint life insurance reserve tables. Furthermore, according to Kele [8] premium reserves calculated using the Canadian method increase with the age of the insured. The prospective method has become the standard in setting life insurance premiums, with a focus on estimating future risks and claims.

On the other hand, the Canadian method, as an extension of the prospective approach, offers added advantages by accounting for premium modifications and extending the modification period. This study will adopt a comparative approach to evaluate the premium reserve values between the prospective and Canadian methods, taking into account different premium payment periods. This scheme is regarded as attractive from an actuarial and policyholder perspective, as it allows the insured to pay premiums over a limited number of years while still being entitled to death benefits throughout their entire lifetime. By comparing these two methods, the study aims to identify differences in the resulting premium reserve values whole life insurance.

2 Material and Methods

Mortality Table

A mortality table contains several components, such as l_x, which represents the number of people alive at age x, d_x which indicates the number of people who die at age x and q_x which denotes the probability that a person aged x will die between age x and$x + 1$. Mortality tables are used by insurance companies to calculate premiums, as they include key components that are essential in determining premium rates. To facilitate calculations within the mortality table, commutation functions are commonly used. These functions are typically applied in the calculation of annuities, actuarial present values, premium reserves, and related computations [9].

$$D_x = v^x . l_x \quad (1)$$

$$C_x = v^{x+1} . d_x \quad (2)$$

$$N_x = \sum_{i=0}^{n} D_{x+i} \quad (3)$$

$$M_x = \sum_{i=1}^{n} C_{x+i} \tag{4}$$

Actuarial Present Value for Whole Life Insurance

The net single premium for whole life insurance is a one-time lifetime premium payment for a policyholder aged x, denoted by A_x, and is expressed using commutation symbols as follows [8]:

$$A_x = \frac{M_x}{D_x} \tag{5}$$

Life Annuity

An annuity is a series of fixed payments made at regular intervals, such as monthly, quarterly, semi-annually, or annually. A life annuity includes a survival factor, meaning it is contingent upon the policyholder's life expectancy [10]. The present value of a life annuity, with payments made at the beginning of each year, is denoted as:

$$\ddot{a}_x = \frac{N_x}{D_x} \tag{6}$$

$$\ddot{a}_{x:\overline{n}|} = \frac{N_x - N_{x+n}}{D_x} \tag{7}$$

Whole Life Insurance Premium

A premium is the amount of money paid by the insured to the insurer, as predetermined in the insurance agreement [5]. The annual whole life insurance premium for a person aged x is calculated as:

$$P_x = \frac{A_x}{\ddot{a}_x} = \frac{M_x}{N_x} \tag{8}$$

Premium payments can also be made over a certain period h, and are denoted as:

$$_hP_x = \frac{A_x}{\ddot{a}_{x:\overline{h}|}} = \frac{M_x}{N_x - N_{x+h}} \tag{9}$$

Prospective Premium Reserves

The prospective premium reserve is calculated based on the present value of all future income and outgoings [11]. The reserve at time n is the difference between the present value of total future benefits (claims) and the present value of total future premiums at time n. If x is the age of the insured at the start of the contract, then the prospective reserve at the end of year k is given by [14]:

$$ {}_{k}^{h}V_x = \begin{cases} A_{x+k} - {}_hP_x\ddot{a}_{x+k:\overline{h-k|}} & k < h \\ A_{x+k} & k \geq h \end{cases} \tag{10} $$

Canadian Premium Reserves

The Canadian reserve method calculates reserves by aligning the modified initial premium with the net premium, adjusted by the difference between the net premium and the natural premium. The modified premium is denoted by α for the first year and β for subsequent years [15].

The modified first-year premium in the Canadian method is:

$$ \alpha = {}_hP_x - \left(P_x - \frac{C_x}{D_x}\right) $$

Here, $\frac{C_x}{D_x}$ represents the natural premium, which is a renewable one-year term premium, extended annually over a specific premium payment period. The present value of the total net premiums at the start of the insurance contract equals the present value of the total expected gains from the contract.

$$ {}_hP_x\ddot{a}_{x:\overline{h|}} = \alpha + \beta\left(\ddot{a}_{x:\overline{h|}} - 1\right) $$

The extended modified premium β is expressed as:

$$ \beta = {}_hP_x + \frac{P_x - \frac{C_x}{D_x}}{\ddot{a}_{x:\overline{h|}} - 1} \tag{11} $$

The β is used as the annual premium in Canadian reserve calculations, which are influenced by the number of payments h

$$ {}_{k}^{h}V_{x}^{can} = \begin{cases} A_{x+k} - \beta \ddot{a}_{x+k:\overline{h-k}|} & k < h \\ A_{x+k} & k \geq h \end{cases} \quad (12) $$

Research Parameters

This study uses a fixed interest rate of 5.75%, as set by Bank Indonesia in April 2025 [12]. The mortality data used in the calculations is sourced from the 2023 Indonesian Male Mortality Table (TMPI 2023)[13].

Methods

1. Define the age of the policyholder (insured), which is 25 years.
2. Determine the probability of death and the remaining unknown elements of the mortality table.
3. Calculate the commutation values.
4. Compute the actuarial present values.
5. Calculate the initial annuity values for whole life insurance.
6. Compute the whole life insurance premiums for different premium payment periods ($h = 5,10,20$)
7. Calculate the prospective premium reserves for different payment durations ($h = 5,10,20$)
8. Determine the modified premiums α and β for the Canadian method with various premium payment periods.
9. Calculate the Canadian premium reserves for each duration.
10. Analyze and compare the results from the prospective and Canadian reserve methods

3 Results and Discussions

In the calculation of premium reserves for whole life insurance, an insured individual aged 25 is selected. The researcher chooses the age of 25 because policyholders at this age are generally at their peak performance, both in terms of health and work. In addition, the researcher uses data from Indonesian Male Mortality Table (TMPI 2023) [13] and interest rates from Bank Indonesia (5,57% in April 2025) [12].

The calculation of the commutation value D_x or the present value of payments for the number of insured individuals alive at age x, using a constant interest rate, is performed using Equation (1). The calculation of the present value of payments, or C_x or the number of insured individuals who die at age x = 25 to x = 110, is done using Equation (2). The value N_x is the accumulation of D_{x+i} for $i = 0$ up to $\omega = 110$. Equation (3) is used to calculate N_x. The value M_x is the accumulation C_{x+i} for $i = 0$ up to $\omega = 110$. Equation (4) is used to calculate M_x. The results of the commutation values are shown in Table 1.

The present value of whole life insurance is calculated using Equation (5) and is shown in Table 2. After obtaining the present value of whole life insurance, the calculation of whole life annuities and term life annuities can be carried out using Equations (6) and (7), as shown in Tables 3 and 4. The value of the term annuity increases as the premium payment period lengthens, with $h = 20$ having the highest term annuity value.

Table 1. Commutation Values, N_x, C_x, M_x

x	D_x	N_x	C_x	M_x
25	24.027,8	403.218	24,4481	1.785,73

Table 2. Actuarial Present Value

x	A_x
25	0,08754

Table 3. Whole Life Annuity

x	$\ddot{a}_x$
25	16,7813

Table 4. Term Annuity

x	h	$\ddot{a}_{x:\overline{h}\|}$
25	5	4,4754
	10	7,8371
	20	12,2385

. After obtaining the present value of whole life insurance and life annuities, the premium value of whole life insurance and the premium value of whole life insurance paid over a period of h are calculated using Equations (8) and (9), as shown in Tables 5 and 6. The value of the whole life premium decreases as the premium payment period lengthens, with $h = 20$ having the lowest premium value.

Table 5. Whole Life Premium

x	P_x
25	0,00522

Table 6. Premium payment over a period of h year

x	h	${}_hP_x$
25	5	0,01956
	10	0,01117
	20	0,00715

Before determining the premium reserves using the Canadian method, the prospective reserve value is also calculated for comparison using Equation (10). The reserves are calculated over a 10-year period, from $t = 0$ to $t = 10$. The results of the prospective reserves for various premium payment periods are shown in Table 7. Subsequently, the calculation of the value of β which is the modified premium, is carried out using Equation (11), as shown in Table 8. After obtaining the modified premium, the calculation of premium reserves using the Canadian method can be performed using Equation (12). The reserves are also calculated over a 10-year period, from $t = 0$ to $t = 10$.

Table 9 shows a decrease in premium reserve values as the premium payment period increases. In addition, the reserve value from the Canadian method is lower than the prospective method. The Canadian method uses a modified premium reserve, which is based on a modified premium β, as the foundation for reserve calculation. With higher premiums charged in the early years, the reserve during that period become smaller. Overall, the smaller reserve values under the Canadian method do not indicate that the method is less reliable, but rather reflect a different funding strategy in premium reserve formation.

Table 7. Prospective Premium Reserves

k	${}^{5}_{k}V_{25}$	${}^{10}_{k}V_{25}$	${}^{20}_{k}V_{25}$
0	0	0	0
1	0,01963	0,01075	0,00650
2	0,04036	0,02207	0,01332
3	0,06224	0,03400	0,02047
4	0,08535	0,04656	0,02799
5	0,10976	0,05980	0,03588
6	0,11484	0,07376	0,04418
7	0,12015	0,08848	0,05289
8	0,12570	0,10399	0,06204
9	0,13151	0,12034	0,07166
10	0,13759	0,13759	0,08176

Table 8. Modified premium

x	α	h	β
25	0,00697	5	0,02077
		10	0,01178
		20	0,00753

Table 9. Canadian Premium Reserves

k	${}_{k}^{5}V_{25}^{can}$	${}_{k}^{10}V_{25}^{can}$	${}_{k}^{20}V_{25}^{can}$
0	-0,00541	-0,00481	-0,00457
1	0,01518	0,00630	0,00205
2	0,03693	0,01801	0,00901
3	0,05989	0,03035	0,01631
4	0,08414	0,04335	0,02397
5	0,10976	0,05705	0,03202
6	0,11484	0,07150	0,04049
7	0,12015	0,08674	0,04938
8	0,12570	0,10279	0,05872
9	0,13151	0,11973	0,06853
10	0,13759	0,13759	0,07884

4 Conclusions

The findings demonstrate differences between the Canadian method and the Prospective method in calculating premium reserves for whole life insurance. Reserve values calculated using the Canadian method are lower than the Prospective method, primarily due to the modified premium structure. Additionally, the analysis indicates a decreasing trend in reserve values as the premium payment period increases. This reduction in reserve requirements implies advantageous for actuaries and policymakers aiming to promote affordability and broaden insurance coverage, but it requires careful risk management to maintain solvency.

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References

[1] B. J. Siregar, A. Saragih, H. Maryani, and A. Halim, "Aspek Hukum Terkait Dengan Perjanjian Asuransi Menurut Kitab Undang-Undang Hukum Perdata," *Jurnal Rectum: Tinjauan Yuridis Penanganan Tindak Pidana*, vol. 5, no. 3, p. 299, Aug. 2023, doi: 10.46930/jurnalrectum.v5i3.3641.

[2] H. Darmawi, *Manajemen Risiko*. 2022.

[3] W. H. Sadli, "Penentuan Cadangan Premi Asuransi Jiwa Dwiguna dengan Metode Zillmer dan Metode Illinois pada Kasus Joint Life," 2023.

[4] D. Badruzaman, "Perlindungan hukum tertanggung dalam pembayaran klaim asuransi jiwa," *Amwaluna: Jurnal Ekonomi dan Keuangan Syariah*, pp. 96–118, 2019.

[5] Darma Ekawati and Fardinah, "Penentuan Cadangan Premi Asuransi Jiwa Bersama Dwiguna dengan Metode Canadian," *Journal of Mathematics: Theory and Applications*, pp. 1–4, Aug. 2020, doi: 10.31605/jomta.v2i1.748.

[6] A. Olivieri and E. Pitacco, *Introduction to Insurance Mathematics*, Second Edition. Springer, 2015.

[7] D. P. Sari and D. Ekawati, "Cadangan Canadian Asuransi Jiwa Dwiguna dengan Penerapan Hukum Mortalitas De Moivre," *Journal of Mathematics: Theory and Applications*, pp. 35–39, 2022.

[8] F. Pasriyane Kele, T. Manurung, D. Tineke Salaki, K. Kunci, and A. Jiwa Semur Hidup Cadangan Premi Metode Canadian, "Penentuan Cadangan

Premi Asuransi Jiwa Seumur Hidup Menggunakan Metode Canadian." [Online]. Available: https://ejournal.unsrat.ac.id/index.php/decartesian

[9] F. S. Ibrahim, "Penentuan Cadangan Premi pada Asuransi Jiwa Berjangka Status Joint Life Menggunakan Metode Canadian," *Journal of Mathematics UNP*, vol. 7, no. 1, p. 19, Mar. 2022, doi: 10.24036/unpjomath.v7i1.10870.

[10] S. Fatimah, N. Satyahadewi, and S. Martha, "Penentuan Nilai Anuitas Jiwa Seumur Hidup Menggunakan Distribusi Gompertz," 2016.

[11] M. R. Oktavian, D. Devianto, and F. Yanuar, "Kajian Metode Zillmer, Full Preliminary Term, Dan Premium Sufficiency Dalam Menentukan Cadangan Premi Pada Asuransi Jiwa Dwiguna."

[12] "BI-Rate Tetap 5,75%: Mempertahankan Stabilitas, Mendukung Pertumbuhan Ekonomi." Bank Indonesia. https://www.bi.go.id/id/publikasi/ruang-media/news-release/Pages/sp_278425.aspx (accessed May 1st 2025)

[13] "Tabel Mortalitas dan Morbiditas Penduduk Indonesia Tahun 2023 dari BPJS Kesehatan". The Society of Actuaries of Indonesia. https://www.aktuaris.or.id/page/news_detail/251/tabel-mortalitas-dan-morbiditas-penduduk-indonesia-tahun-2023-dari-bpjs-kesehatan (accessed March 4th 2025)

[14] N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones, and C. J. Nesbitt, *Actuarial Mathematics*, Second Edition. The Society of Actuaries, 1997.

[15] N. Hasnah, "Kajian Metode Commissioners, Illinois dan Canadian dalam Menentukan Cadangan Pada Asuransi Jiwa Dwiguna," *Jurnal Matematika UNAND*, vol. 4, no. 4, pp. 99–106, Jul. 2019, doi: 10.25077/jmu.4.4.99-106.2015.