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Estimation of Inpatient Health Insurance Premiums using the RP-2000 Table with Medical Cost Projection Scenario

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ABSTRACT

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Inpatient health insurance serves as an essential form of financial protection to mitigate the risk of loss arising from hospitalization costs. This study aims to estimate inpatient health insurance premiums by combining the Indonesian Mortality Table IV and the RP-2000 Combined Healthy Table to determine age-specific hospitalization probabilities. Methodologically, this research employs a quantitative actuarial modeling approach based on life table techniques and expected present value calculations, using secondary data from the Indonesian Mortality Table IV, the RP-2000 Combined Healthy Table, and published information on medical inflation in Indonesia. The numerical illustrations are obtained through spreadsheet-based actuarial calculations. In addition to age, the premium calculation incorporates the interest rate, the insured's gender, and cost components such as inpatient care, surgery, and intensive care unit (ICU) treatment so that the premium structure aligns with the coverage provided. A scenario of rising hospital costs due to medical inflation, assumed at 13% per year, is also included to obtain more realistic and economically relevant premium estimates. A case study is conducted for a 30-year-old participant with a two-year coverage period, offering benefits of an inpatient daily allowance of IDR 300,000 (maximum 40 days), surgical expenses up to IDR 3,000,000, miscellaneous hospital care up to IDR 7,000,000, and an ICU allowance of IDR 600,000 per day (maximum 15 days). The analysis results show monthly premiums of IDR 113,341 for male participants and IDR 121,904 for female participants, where the difference is attributed to higher hospitalization risks among females. Age variation analysis indicates that premiums increase with age, while interest rate variation analysis shows that higher interest rates result in lower premiums due to the discounting effect. These findings support the need for a dynamic actuarial approach to setting more accurate and sustainable health insurance premiums.

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1. Introduction

Health constitutes a fundamental asset in human life, as it underpins both productivity and overall quality of life [1]. Nevertheless, health conditions have become increasingly unpredictable due to environmental influences and unhealthy lifestyle choices [2]. Consequently, maintaining good health is imperative for every individual. A sound state of health not only enhances personal well-being but also plays a critical role in ensuring financial stability, particularly in relation to the rising costs of medical care [3].

The risk of illness or accidents requiring medical treatment has continued to rise [4], amidst the increasing cost of healthcare services a global challenge, particularly for low income populations [5]. According to World Bank data (2022) more than 100 million people fall into poverty each year due to unaffordable healthcare expenses. While no one anticipates becoming ill, it remains essential to be financially prepared for potential medical and hospitalization costs. Over the years, healthcare expenses have consistently increased, including those for medical check-ups, treatment, and inpatient care. Based on a 2021 survey conducted by the Global Medical Centre, nearly half (49%) of leading global insurance providers predicted that healthcare costs would remain stable over the next three years, whereas 40% projected a continued increase in medical expenses [6].

One of the key solutions to protect individuals from the financial risks associated with high medical and treatment costs is through the purchase of health insurance [7]. In Indonesia, increasing awareness of health protection has driven the growth of the health insurance industry, particularly inpatient care services [8]. Unlike life insurance, which focuses on death benefits, health insurance provides coverage for medical expenses, hospital treatment, and even surgical procedures [9].

In general, health insurance is classified into two main services types: outpatient and inpatient care. Inpatient health insurance provides financial compensation to policyholders to cover the costs of treatment and care in the event of unavoidable illnesses [10]. On the other hand, outpatient services cover expenses such as medical consultations, laboratory diagnostic test, physiotherapy, and medication, without requiring hospitalization. The extent of coverage provided by health insurance is typically subject to a maximum limit within a given period, both in terms of claim amounts and the frequency of visits to healthcare facilities.

A primary challenge in health insurance systems lies in determining the optimal premium amount-one that remains affordable for the public while ensuring the financial sustainability of insurance providers [11]. The premium must accurately reflect the risks borne by the insured, while also supporting the long-term viability of the insurance program [12]. Premiums that are set excessively high have the potential to reduce public participation in insurance programs, whereas premiums that are set too low may pose a threat to the financial sustainability of insurance providers [13]. Therefore, an actuarial method is required that comprehensively accounts for participant risk factors such as age, gender, medical history, and projected annual increases in medical costs [14].

Several previous studies have examined the calculation of health insurance premiums, including individual inpatient premium estimation [7], monthly individual insurance premiums [15,16], and collective premiums for term insurance policies [17]. Additionally, companies such as Panin Dai-Ichi Life have developed products based on individual risk profiles to provide more equitable and personalized health protection [18]. Nevertheless, most existing research still relies on a single mortality table and does not fully incorporate the impact of actual medical inflation.

This study offers novelty through two main approaches. First, it utilizes a combination of the Indonesian Mortality Table IV and the RP-2000 Combined Healthy table to more accurately estimate health risks. The Indonesian Mortality Table IV is constructed from recent insured-lives data contributed by Indonesian life insurers and is promoted by the Indonesian Life Insurance Association (AAJI) as an official reference for determining premium rates that better reflect current characteristics of the Indonesian population and produce more accurate tariffs for the domestic market [19]. The RP-2000 Combined Healthy table, developed by the Society of Actuaries from a large dataset of pension and insured lives, has become an international benchmark for pricing and valuation because of its detailed age- and gender-specific mortality rates and well-documented construction methodology [20]. Second, this study incorporates scenarios of hospital cost increases by accounting for medical inflation, which was reported to reach around 13–13.6% in Indonesia in 2023 [21]. Furthermore, this approach considers specific cost components such as inpatient care, surgery, and intensive care unit (ICU) treatment to produce a more realistic and relevant premium aligned with actual protection needs. Based on this background, the objective of this study is to calculate individual inpatient health insurance premiums using an actuarial approach based on a combination of mortality tables and medical inflation, while also providing an alternative solution for fair and sustainable premium determination in Indonesia's health insurance industry.

2. Research Methods

There are several commutation functions that are widely applied in the calculation of life insurance values [22], these functions serve as essential tools for simplifying the computation of present values and other actuarial quantities, it's include:

a. The number of individuals alive at exact age x tis denoted by l_x.

b. The number of individuals who die between age x and $x+1$ is denoted by d_x, defined as:

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

c. The probability that an individual aged x survives to age $x+n$ is denoted by ${}_np_x$, given by:

$${}_np_x = \frac{l_{x+n}}{l_x} \tag{2}$$

d. The probability that an individual aged x dies before reaching age $x+n$ is denoted by ${}_nq_x$, and defined as:

$${}_nq_x = 1 - {}_np_x = \frac{l_x - l_{x+n}}{l_x} \tag{3}$$

e. The discount factor based on an interest rate (i) is denoted by v, defined as:

$$v = \frac{1}{1+i} \tag{4}$$

f. The product of the discount factor to the power of age x and the number of individuals alive at age x is defined as:

$$D_x = v^x \cdot l_x \tag{5}$$

g. The limiting age in the mortality table is denoted by ω.

h. The accumulation of all D_x values from age x to the limiting age is given by:

$$N_x = D_x + D_{x+1} + \cdots + D_\omega = \sum_{k=0}^{\omega-x} D_{x+k} \tag{6}$$

i. The product of the discount factor to the power of $x+1$ and the number of individuals dying at age x is defined as:

$$C_x = v^{x+1} \cdot d_x \tag{7}$$

j. The accumulation of all C_x values from age x to the limiting age is denoted as:

$$M_x = C_x + C_{x+1} + \cdots + C_\omega = \sum_{k=0}^{\omega-x} C_{x+k} \tag{8}$$

An annuity refers to a series of fixed payments made at regular intervals over a specified period of time [23]. These payments may occur weekly, monthly, annually, or at other predefined intervals. A fundamental characteristic of an annuity is that the regular payments accumulate interest over time, and the disbursement continues for as long as the insured individual remains alive.

There are various types of life annuities, including whole life annuities, temporary (or term) annuities, and pure endowments. Annuity payments may be made at the beginning of each year, referred to as an annuity-due, or at the end of each year, referred to as an annuity immediate. A whole life annuity is defined as a series of payments made for as long as the insured individual remains alive. The present value of a life annuity-immediate with a unit payment for an individual aged x can be calculated using the following formula:

$$a_x = \frac{N_{x+1}}{D_x} \tag{9}$$

Meanwhile, the life annuity-due is defined by the following expression:

$$\ddot{a}_x = \frac{N_x}{D_x}. \tag{10}$$

If a series of payments is made over a limited period, it is referred to as a temporary annuity (or term annuity). In a term annuity-immediate, payments are made at the end of each policy year, with a total of n payments. The present value of such an annuity is given by the following formula:

$$a_{x:n\rceil} = \frac{N_{x+1} - N_{x+n+1}}{D_x} \tag{11}$$

Meanwhile, the present value of a term life annuity-due is given by the following expression:

$$\ddot{a}_{x:n\rceil} = \frac{N_x - N_{x+n}}{D_x} \tag{12}$$

A life annuity with m payments per year refers to an annuity in which payments are made at interval $1/m$ years. For example, if payments are made monthly, then $m = 12$. The present value of a life annuity-due or annuity immediate for an individual aged x, with m payments per year over a term of n years, is expressed as follows:

$$\ddot{a}^{(m)}_{x:n\rceil} = \frac{N_x - N_{x+n}}{D_x} - \frac{m-1}{2m}\left(1 - \frac{D_{x+n}}{D_x}\right) \tag{13}$$

$$a^{(m)}_{x:n\rceil} = \frac{N_{x+1} - N_{x+n+1}}{D_x} - \frac{m-1}{2m}\left(1 - \frac{D_{x+n+1}}{D_x}\right). \tag{14}$$

Monetary compensation for medical treatment and care in the event of an undersirable illness. A premium refers to the amount of money that must be paid by the insured to the insurance provider (the insurer), in accordance with the terrms outlined in the insurance policy [24]. The premium may be paid as a lump sum (single premium) or on a periodic basis-such as annually, semiannually, or monthly-depending on the aggrement.

The net single premium is paid once at policy inception (time 0). During the n-year coverage period, benefit payments for inpatient care, surgery, and ICU treatment may arise in any policy year whenever the insured experiences the corresponding health event. Therefore, the net single premium is equal to the actuarial present value of the expected stream of benefit payments over years $1, \dots, n$, which can be written as

$$R = R_{\text{inpatient}} + R_{\text{surgery}} + R_{\text{ICU}}$$

Each term on the right-hand side represents the present value of the stream of expected payments for the corresponding benefit over the n-year term, discounted at the effective annual interest rate i. Equation (15) provides the detailed expression for R inpatient; analogous expressions are obtained for the surgery and ICU benefits. The net single premium for inpatient hospital care can be expressed as follows [25]:

$$\begin{aligned}(RA'_{x:n\rceil}) &= v^{\frac{1}{2}} q_x^{sh} T^{sh} + v^{1+\frac{1}{2}} {}_1p_x q_{x+1}^{sh} T^{sh} + v^{2+\frac{1}{2}} {}_2p_x q_{x+2}^{sh} T^{sh} + \cdots \\ &\quad + v^{(n-1)+\frac{1}{2}} {}_{n-1}p_x q_{x+(n-1)}^{sh} T^{sh} \\ &= T^{sh}\Big\{ v^{\frac{1}{2}} q_x^{sh} + v^{1+\frac{1}{2}} {}_1p_x q_{x+1}^{sh} + v^{2+\frac{1}{2}} {}_2p_x q_{x+2}^{sh} + \cdots \\ &\quad + v^{(n-1)+\frac{1}{2}} {}_{n-1}p_x q_{x+(n-1)}^{sh} \Big\} \\ &= T^{sh} \sum_{t=0}^{n-1} \left(v^{t+\frac{1}{2}}\right) ({}_tp_x)(q_{x+t}^{sh})\end{aligned} \tag{15}$$

The age of the insured, in years, is denoted by x, while the term of the insurance coverage is represented by n. The discount factor based on the interest rate is denoted by v. The probability that an individual will require hospitalization within one year is denoted by ${q_x}^{sh}$, while the probability of hospitalization after one year is denoted by ${q_{x+1}}^{sh}$. The avreage duration of hospitalization is expressed as T^{sh}, and the probability that an individual aged x survives one additional year is represented by ${}_1p_x$. Time, measured in years, is denoted by t, and the benefit or compensation provided by the insurance is denoted by R.

In general, health insurance premiums for hospital care are paid on an annual basis. Moreover, the premium amount is influaneced by factors such as the insured's age and gender. Although some policies require a single premium payment, the majority of policyholders pay premiums at the beginning of each specified period such as monthly or at other regular intervals a system, commonly refered to as installment payments. Annual and pro rata premius are typically paid at a fixed rate from year to year.

If the net premium for hospital care health insurance is paid annually [26], then:

$$P\left(A'_{x:n]}\right) = \frac{RA'_{x:n]}}{\ddot{a}_{x:n]}} = \frac{T^{sh}\sum_{t=0}^{n-1} v^{t+\frac{1}{2}}\left(\frac{l_{x+t}}{l_x}\right)(q_{x+t}^{sh})D_x}{N_x - N_{x+n}}$$

$$= \frac{T^{sh}\sum_{t=0}^{n-1} v^{x+t+\frac{1}{2}}(l_{x+t})(q_{x+t}^{sh})}{N_x - N_{x+n}}$$

$$= \frac{T^{sh}\sum_{t=0}^{n-1}(D_{x+t})(q_{x+t}^{sh})}{N_x - N_{x+n}} \tag{16}$$

The monthly premium, paid at the beginning of each month over a period of n years by an insured individual aged x, can be expressed as follows:

$$P\left(A_{x:n]}^{(12)}\right) = \frac{RA'_{x:n]}}{12\ddot{a}_{x:n]}^{(12)}} = R\frac{T^{sh}\sum_{t=0}^{n-1}(D_{x+t})(q_{x+t}^{sh})}{12\left[N_x - N_{x+n} - \frac{11}{24}(D_x - D_{x+n})\right]} \tag{17}$$

3. Results And Discussion

This study employs secondary data, whre individual mortality probabilities are obtained from the Indonesian Mortality Table IV [19], while the probabilities of illness or hospitalization refer to the RP-2000 Combined Healthy Table [20]. The subject of the study is a male insurance participant aged 30 years, with a coverage period of 2 years. An annual interest rate of 6% is applied. The details of the insurance benefits are based on information provided in a brochure by the Independent Insurance Agent Center, which include:

1. Inpatient hospitalization benefit of to IDR 300,000 per day, with a maximum of 40 days;
2. Surgical expense benefit up to IDR 3,000,000;
3. Miscellaneous hospital care costs with a maximum benefit of IDR 7,000,000; and
4. Intensive care unit (ICU) benefit of IDR 600,000 per day, for a maximum of 15 days.

The calculation steps are as follows:

a. Present value of a life annuity-due with monthly payments over a 2-year term:

$$N_{30} = \sum_{t=0}^{110-30} D_{30+t} = 3.368.163$$

$$N_{32} = \sum_{t=0}^{110-32} D_{32+t} = 891.177$$

$$a_{30:2]}^{(12)} = \frac{N_{30} - N_{30+2}}{D_{30}} - \frac{12-1}{24}\left(1 - \frac{D_{30+2}}{D_{30}}\right)$$

$$= \frac{N_{30} - N_{30+2}}{D_{30}} - \frac{12-1}{24}\left(1 - \frac{D_{30+2}}{D_{30}}\right) = 1{,}84$$

b. Net single premium for 2-year term hospital care insurance:

$$P(A'_{30:2]}) = \left(Rp110.000 + Rp300.000 + \frac{1}{365}[Rp700.000]\right)\frac{1}{N_{30}-N_{30+2}}\sum_{t=0}^{2-1}(D_{30+t} \times q_{30+t}^{sh})$$

$$= Rp1.959.887$$

c. Net single premium adjusted for medical inflation of 13% per annum:

$$P^*(A'_{30:2]}) = P(A'_{30:2]}) \times (1+13\%)^2 = Rp2.502.579$$

d. Monthly premium for 2-year term hospital care insurance:

$$P(A_{30:2]}^{(12)}) = \frac{Rp2.458.482}{12 \times 1{,}84} = Rp113.341$$

Table 1 presents the results of the premium calculations for inpatient hospital health insurance, with variations in age, interest rate, and coverage period.

Table 1. Inpatient Health Insurance Premium Variability

Age	Interest Rates (%)	Monthly Premium							
		Male				Female			
		$n = 2$ years		$n = 5$ years		$n = 2$ years		$n = 5$ years	
20 years old	4.00	IDR	92,857	IDR	75,031	IDR	99,873	IDR	80,699
	5.00	IDR	90,992	IDR	73,524	IDR	97,867	IDR	79,077
	6.00	IDR	89,163	IDR	72,047	IDR	95,900	IDR	77,489
30 years old	4.00	IDR	118,037	IDR	95,381	IDR	126,955	IDR	102,583
	5.00	IDR	115,665	IDR	93,458	IDR	124,405	IDR	100,521
	6.00	IDR	113,341	IDR	91,582	IDR	121,904	IDR	98,502
40 years old	4.00	IDR	150,045	IDR	121,240	IDR	161,381	IDR	130,400
	5.00	IDR	147,030	IDR	118,804	IDR	158,138	IDR	127,778
	6.00	IDR	144,075	IDR	116,416	IDR	154,961	IDR	125,212

Based on the case simulation presented in Table 1 and Figure 1, monthly net premium for male participants increases with age. This is understandable, as advancing age is associated with a higher risk of health complications and hospitalization [20]. Furthermore, as the interest rate increases, the required premium decreases, which can be attributed to the effect of the discounting function. For a given age, gender, and interest rate, the monthly premium for a 5-year term is lower than that for a 2-year term because the net single premium is spread over a longer payment period. As shown in Table 1, the premiums for female participants are higher than those for male participants at the same age and interest rate, reflecting higher hospitalization probabilities for females in the RP-2000 Combined Healthy Table.

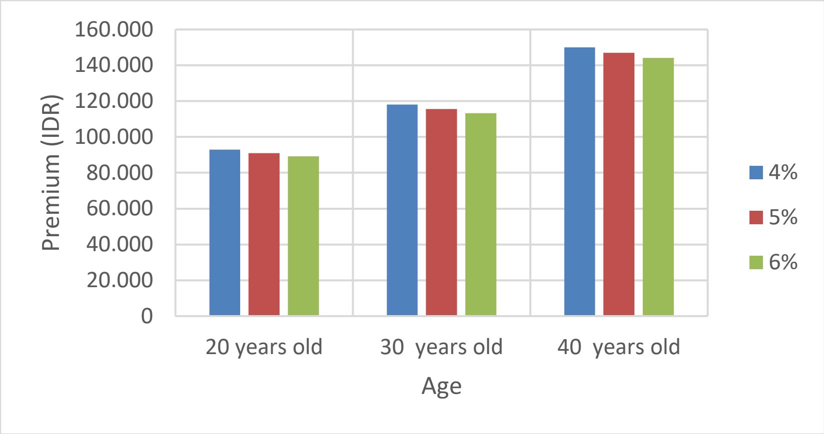

Figure 1. Monthly inpatient health insurance premiums for male participants by age and interest rate (policy term $n = 2$ years)

Figure 1 graphically illustrates the effect of age and interest rate on the monthly net premium for male participants with a two-year coverage period. For each interest rate, the monthly premium increases as the participant's age rises from 20 to 40 years, reflecting the higher risk of hospitalization at older ages. Conversely, within each age group, the premium decreases as the interest rate increases from 4% to 6%, which is consistent with the discounting effect that lowers the actuarial present value of future benefit payments. These patterns confirm the relationships observed in Table 1 for male participants.

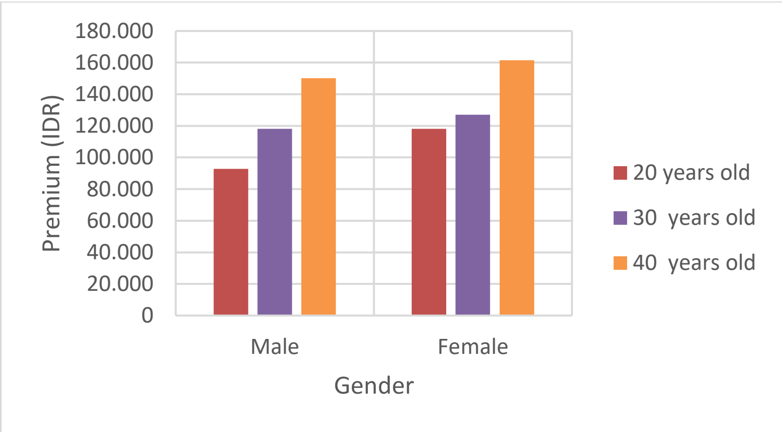

Figure 2. Monthly inpatient health insurance premiums by gender and age (policy term $n = 2$ years and interest rate $i = 4\%$).

Figure 2 compares the monthly net premiums for male and female participants across different ages. For each age group (20, 30, and 40 years), the premium for female participants is higher than that for male participants. This difference widens at older ages and reflects the higher hospitalization probabilities for females than for males at the same age in the RP-2000 Combined Healthy Table. In addition, for both genders the premium increases with age, which is consistent with the results presented in Table 1.

4. Conclusions

Based on the results of this study, the research objectives stated in the introduction have been achieved. First, by combining the Indonesian Mortality Table IV and the RP-2000 Combined Healthy Table with a medical inflation scenario of 13% per year, this study successfully develops an actuarial model for calculating individual inpatient health insurance premiums. The model explicitly incorporates hospitalization probabilities and projected hospital costs for inpatient care, surgery, and ICU treatment, so that the resulting premiums better reflect actual protection needs. Second, the empirical results show that the calculated premiums vary systematically with age, gender, interest rate, and rising medical costs, and that female participants tend to have higher premiums than males at the same age due to higher hospitalization probabilities. These findings indicate that the proposed model can serve as an alternative framework for fair and sustainable premium determination in Indonesia's health insurance industry, helping insurers set premiums that are both actuarially sound and aligned with the affordability and protection needs of the insured.

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