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PREMIUMS CALCULATION OF TERMINAL ILLNESS INSURANCE

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ABSTRACT

One related type of critical illness insurance is Long Term Care (LTC) Insurance. This study discusses the calculation of LTC insurance premiums with an annuity as a rider benefit. The benefit is included the cost of insurance care when diagnosed with a critical illness with a terminal condition or death because of any reason. The types of critical illnesses used in this study are cancer, heart disease, stroke, and diabetes mellitus. The data used are in the form of Indonesia's 2019 *mortality table, and data on the prevalence of critical illness patients with terminal illness conditions. The net annual premium value in this study was obtained through the results of the multiple-state model determination of the transition probabilities of 10 states. The transition probability of an insured candidate is obtained from the prevalence of critical illness patients and the prevalence of mortality. Based on the case study, the net annual premium that must be paid by an insured female aged* 35 *years in good health is* IDR 1,002,199 *for the protection period, and the payment period is* 10 *years. The cost of insurance premiums for the male insured is greater than for the female insured. The higher the interest rate used, the smaller the net single premium that must be paid. The younger the age when registering the policy, the smaller the premium must be paid. The longer the coverage period, the greater the premium that must be paid. This result is expected to be a recommendation for the prospective insured to adjust the suitable premium.*

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1. INTRODUCTION

Insurance means coverage, or it can also be interpreted as a voluntary desire to determine a small loss as a substitute for a large loss that is uncertain in the future[10]. The type of insurance used in this study is life insurance. Life insurance was chosen because of the high number of unexpected cases involving life problems. The case, as an example, is pandemics, high rates of critical illness sufferers, or accidents that can cause death [7]. The type of life insurance used is term life insurance. This type of insurance provides coverage for a certain period called the policy term [12].

One type of insurance related to critical illness conditions is Long Term Care (LTC) insurance [11]. This study discusses the calculation of LTC insurance premiums with an annuity as a rider benefit. The benefits provided the compensation related to treatment costs when a critical illness is diagnosed with a terminal condition and when the insured dies. A Terminal condition is a critical illness condition when it has reached the final stage and is diagnosed by a specialist in the related field. The diagnosis must state that the life expectancy is less than 12 months from the time that diagnosis was given, and just taking medication that can relieve the complaint but cannot cure it. The critical illnesses used in this study were cancer, heart disease, stroke, and diabetes mellitus [9].

The coverage benefits previously mentioned are obtained by a prospective insured by paying a premium. Premium is an amount of money determined through an agreement called a policy determined by the insurance or reinsurance company and approved by the policyholder to get several benefits [14]. The determination of the amount of premium to be paid is aimed at realizing cost distribution and obtaining appropriate protection guarantees. There are two types of premiums, that is net premiums and gross premiums [1]. The premium calculation in this study was carried out using a multiple-state model assuming a Markov chain. The multiple-state model was chosen to be applied to the calculation of health insurance premiums because it makes it easier to observe changes in a person's health status by assuming the model follows the Markov chain assumption [5]. Markov chain is a form of the stochastic process model. Markov chain analysis produces transition probabilities that are useful for observing the movement of the observed object. In this study, the object is the health state transition [6]. The result of determining the transition probability of the insured's health state is used to determine the premium that must be paid by a prospective insured according to their respective conditions.

2. RESEARCH METHODS

The data used in this study is the form of the Indonesian Mortality Table 2019 (TMI 2019) and the critical illness with terminal condition prevalence. The first step in this study was to prepare the data on the prevalence of each disease at each age [2]. In this case, the prevalence of each disease at each age is considered the same for both males and females. In other words, each age has the same probability of suffering from a disease. Then, the calculation of mortality prevalence using the mortality percentage data with mortality tables that start from 0 to 75 years old for each gender. The mortality prevalence data will show the probability of death of patients with each disease. The age used in the mortality table to determine the probability of someone dying will be written as x or q_x^i. After the prevalence of each disease and the probability of death are calculated, the next step is to determine a multiple-state model of 10 states that is (1) Healthy, (2) Suffering cancer, (3) Suffering heart disease, (4) Suffering stroke, (5) Suffering diabetes mellitus, (6) Died because of something else, (7) Died because of cancer, (8) Died because of heart disease, (9) Died because of stroke, and (10) Died because of diabetes mellitus. Using the assumption of 10 states, the prevalence of sufferers of each disease and the prevalence of mortality are determined as transition probabilities that will describe the probability of state transition of an insured [3]. The transition probability data is used to calculate the insurance premiums that must be paid to get the complete insurance benefits. The first step that can be taken to determine the amount of the net annual premium is to determine the amount of the net single premium [4]. The net single premiums are calculated with the formulas [13]:

$$P\left(A_{x:n|}^{LTC}\right) = c\sum_{e=1}^{n} v^{e}\ {}_{e-1}p_x^{11}q_{x+e-1}^{1} + \left(\sum_{e=1}^{n} v^{e}\ {}_{e-1}p_x^{11}p_{x+e-1}^{12}\ddot{a}_{x+e:r|}^{22} + CD\right)$$

$$+\left(\sum_{e=1}^{n} v^{e}\ {}_{e-1}p_x^{11}p_{x+e-1}^{13}\ddot{a}_{x+e:r|}^{33}+JD\right)+\left(\sum_{e=1}^{n} v^{e}\ {}_{e-1}p_x^{11}p_{x+e-1}^{14}\ddot{a}_{x+e:r|}^{44}+SD\right)$$
$$+\left(\sum_{e=1}^{n} v^{e}\ {}_{e-1}p_x^{11}p_{x+e-1}^{15}\ddot{a}_{x+e:r|}^{55}+MD\right) \quad (1)$$

The premium calculation is also carried out with variations in the period of coverage, age, interest rate, and gender, so the premium amount varies as well. The results of the various premium calculations can be a recommendation for the prospective insured to adjust the premium that is suitable for them.

3. RESULTS AND DISCUSSION

3.1. The Prevalence and The Death Percentage of Each Disease

The medical world has its characteristic to describe the prevalence of disease and the proportion of the population with certain characteristics (diseases or risk factors) within a certain period. In this study, the research is using the prevalence data from 4 critical diseases, that is, cancer, heart disease, stroke, and diabetes mellitus, which are shown in **Table 1** as follows:

Table 1. The Prevalence and Death Percentage of Each Disease

Types of Diseases	Prevalence	Death Percentage
Cancer	1.79%	13.50%
Heart Disease	1.50%	12.40%
Stroke	10.90%	21.00%
Diabetes Mellitus	1.50%	6.70%

***Data source**: RISKESDAS 2018, WHO, and Kementerian Kesehatan*

The data on the prevalence of diseases and death percentage is important for determining the transition probabilities that are used in calculating insurance premiums to be paid.

3.2. The Death Probability Due to Diseases (Prevalence of Mortality)

The probability of death (prevalence of mortality) in this study is based on the percentage of deaths of patients with each disease in **Table 1** and the Indonesian Mortality Table (TMI 2019). The prevalence of mortality was calculated using Microsoft Excel. Some of the data is shown in **Table 2** and **Table 3** as follows:

Table 2. The Prevalence of Mortality for Male

Age	Probability of Died Due to Diseases				Died Because of Something Else
	Cancer	Heart Disease	Stroke	Diabetes Mellitus	
0	0.000707	0.000650	0.001100	0.000351	0.002431
1	0.000071	0.000066	0.000111	0.000036	0.000246
2	0.000056	0.000052	0.000088	0.000028	0.000195
⋮	⋮	⋮	⋮	⋮	⋮
75	0.002735	0.002512	0.004255	0.001357	0.009401

Table 3. The Prevalence of Mortality for Female

Age	Probability of Died Due to Disease				Died Because of Something Else
	Cancer	Heart Disease	Stroke	Diabetes Mellitus	
0	0.000359	0.000330	0.000559	0.000178	0.001234
1	0.000055	0.000051	0.000086	0.000027	0.000190
2	0.000042	0.000038	0.000065	0.000021	0.000144
⋮	⋮	⋮	⋮	⋮	⋮
75	0.002353	0.002161	0.003660	0.001168	0.008088

The comparison of calculation results in **Table 2** and **Table 3** is shown that the prevalence of mortality for males is higher than for females. As an example, the prevalence of mortality for males in age 75 because of cancer is 0.002735, while for females is 0.002353.The comparison result also shows that the higher the insured age both male and female, the higher the prevalence of mortality.

3.3. The Diagram State Model

This stage uses an example to understand the change of the state transition, using a one-way transition with the 10 states model. The probability of each occurrence in a 35-year-old female insured is shown in the diagram state model in **Figure 1** as follows:

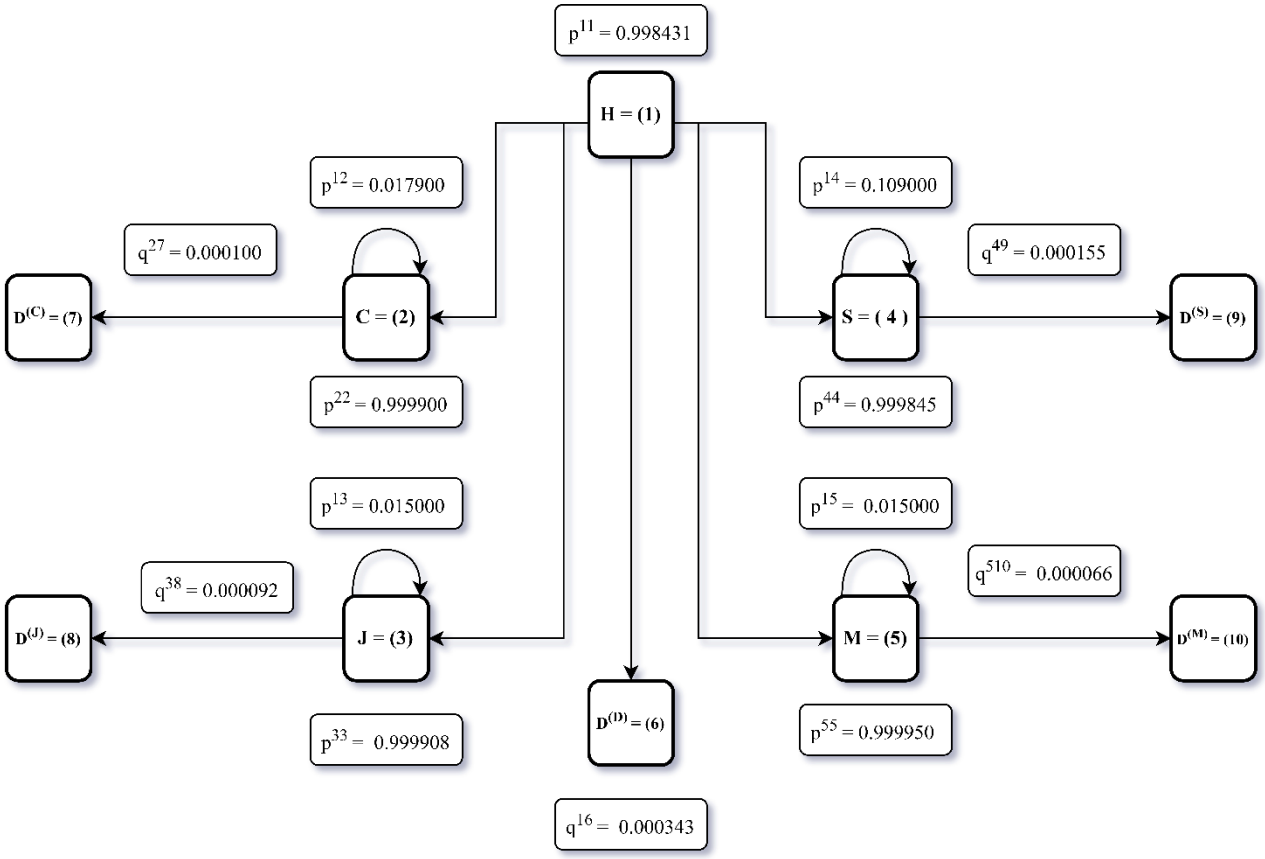

Figure 1. States and Transitions

For example, based on **Figure 1**, if the researchers want to know the magnitude of the transition probability from a healthy state (1) to suffering heart disease (3), it can be seen through the probability of p^{13} which is 0.015000. Meanwhile, to know the magnitude of the transition probability from the state of suffering heart disease (3) to death because of cancer state (8), it can be seen through the probability of q^{38}, which is 0.000092. The changes in the probability transition state for each age in both males and females have the same way. The difference is shown in the magnitude of the probability of transition from one state to another state, influenced by the prevalence of critical illness and the prevalence of mortality.

3.4. The Diagram State Model

The insurance product in this research has two benefits. That is the cost of insurance care when diagnosed with a critical illness with a terminal condition or death because of any reason. For example, this study applies a case study to an insured female at 35 years old with a coverage period of 10 years. Assumptions of the product policy agreement that are used:

1. The insured (policyholder) is a 35 years old female in a good health ($x = 35$).
2. The length of the coverage period is 10 years ($n = 10$ and $e = 10$).
3. If the insured is diagnosed with one or more critical illnesses with a terminal condition during the coverage period, then the insured will receive a maximum treatment benefit as b (IDR 300,000,000).

4. If the insured dies during the insurance period due to any cause (which is not included in the exception), then the insured will receive a maximum sum of $c =$ (IDR 300,000,000).
5. The premium is paid once at the beginning of the payment period or the beginning of each year as long as the insured is in a good health with the BI7DRR reference rate at the time this research was done, which is 3.75% ($r = 0.0375$) [2].

Using the assumptions above, the calculations have been made, and the net single premium for an insured female aged 35 years is IDR 8,473,273 with a net annual premium, that is IDR 1,002,199. The amount of premium to be paid includes the complete benefits of the insurance product.

3.5. The Variation of Premiums Insurance

As a consideration in determining the amount of premium following the benefits obtained, premium calculations are carried out with variation in the coverage period (4, 5, and 10 years), age (25, 35, and 40 years), interest rate (3.75%, 6.00%, and 8.00%), and gender so that the following results are obtained in Table 4 as follows:

Table 4. The Net Annual Premiums with Variations

Age	Net Annual Premiums						r (%)
	4 Years		5 Years		10 Years		
	Male	Female	Male	Female	Male	Female	
25	IDR 152,017	IDR 111,861	IDR 209,210	IDR 155,752	IDR 620,599	IDR 460,786	3.75
	IDR 150,873	IDR 110,969	IDR 208,044	IDR 154,821	IDR 622,268	IDR 462,077	6.00
	IDR 149,848	IDR 110,171	IDR 206,966	IDR 153,965	IDR 623,098	IDR 462,731	8.00
35	IDR 312,076	IDR 231,773	IDR 453,948	IDR 320,068	IDR 1.499,459	IDR 1,002,199	3.75
	IDR 309,669	IDR 230,005	IDR 433,262	IDR 318,255	IDR 1.498,495	IDR 1,002,268	6.00
	IDR 307,515	IDR 228,421	IDR 430,984	IDR 316,581	IDR 1,496,222	IDR 1,000,991	8.00
40	IDR 508,498	IDR 342,914	IDR 732,228	IDR 484,088	IDR 2,564,394	IDR 1,594,218	3.75
	IDR 504,395	IDR 340,236	IDR 727,459	IDR 481,171	IDR 2,563,249	IDR 1,593,970	6.00
	IDR 500,732	IDR 337,841	IDR 732,167	IDR 478,490	IDR 2,599,752	IDR 1,594,920	8.00

Through the calculation of the net annual premium with variations in Table 4, the four variables that were varied also affect the amount of the net single premium that must be paid by a prospective insured.

4. CONCLUSIONS

The net annual premium value in this study was obtained through the result of the multiple-state model determination of the transition probabilities of 10 states that are (1) Healthy, (2) Suffering cancer, (3) Suffering heart disease, (4) Suffering stroke, (5) Suffering diabetes mellitus, (6) Died because of something else, (7) Died because of cancer, (8) Died because of heart disease, (9) Died because of stroke, and (10) Died because of diabetes mellitus. The magnitude of the transition probabilities of a prospective insured is obtained from the prevalence of critical illness and the prevalence of mortality. Based on the case study, the amount of the net single premium that must be paid by an insured female aged 35 years to get an insurance product with benefits for treatment costs when diagnosed with a critical illness with a terminal illness or death is IDR 8,473,273 with a net annual premium that is IDR 1,002,199 for a 10 years coverage period. Through the result of the calculation of premiums with variations, the cost of insurance premiums for the male insured is greater than for the female insured. The younger the age when registering the policy, the smaller the premium that must be paid. The longer the coverage period, the greater the premium that must be paid. The amount of interest rate used affects the value of the annuity because the amount of the net annual premium to be paid depends on the annuity produced. The amount of the net annual premium with variations in interest rates may increase along with the higher interest rates used, but it can also be the opposite, depending on the

amount of the net single premium divided by the annuity at a predetermined interest rate. This result is expected to be a recommendation for the prospective insured to adjust the suitable premium.

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