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Critical Illness Insurance Model for Breast Cancer Patients Based on Chemotherapy Responses

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Abstract The insurance model in the form of Critical Illness (CI) is generally structured by a multi-state model that allows us to describe changes in insurance policies based on status changes experienced. The model in this study discusses the Markov process, which describes the critical illness insurance policy in each state for a continuous-time. Critical illness of breast cancer is modeled by several states consisting of A is healthy or disease-free, B is early cancer, C is cancer increase after chemo, and Y is dead from cancer. This condition is based on the response to treatment after chemotherapy. The first steps in this study are to assign a function to the transition intensity from state to state and the transition probability. The transition probability of the multi-state model is the solution of the Kolmogorov forward differential equation. The following discussion is to create a formula for calculating the pure premium rate based on age intervals. A case study based on medical record data at dr.Sardjito Hospital is applied to calculate insurance premiums based on policies and age groups. A case study based on medical record data at dr.Sardjito Hospital is applied to calculate insurance premiums based on policies and age groups. The premium generated in this study is assumed to only depend on the number and time of state transfers. This insurance model can be an alternative to a more accurate insurance calculation based on the incidence of displacement of critically ill patients, especially breast cancer patients.

Keywords Critical Illness Insurance, Multi State Model, Breast Cancer, Pure Premium Rate, Chemotherapy

1 Introduction

There are various types of health insurance products in the world, and there are many traditions of actuarial calculations that are used. The insurance model in the form of Critical Illness (CI) or Long Term Care (LTC) is generally structured by a multi-state model that allows us to describe changes in insurance policies provided based on status changes experienced. The multi-state model is a model in a continuous stochastic process that discusses the movement of a person in a limited number of states. Status can be in the form of health, illness, or death. This change or transfer of state is called a transition or event.

The complexity of the multi-state model depends very much on the number of states and the transition probability. Transition opportunities from one state to another are formed from the transition intensity. The transition intensity provides the rate of change from one state to another per unit time. The Markov model in the multi-state model is widely used as a basis for the analysis and development of a transitional opportunity model. A person's chance to transition from healthy to sick status or vice versa in the future depends only on his current state.

Several studies on critical illness insurance models have been conducted. Gui and Macdonald [1] have researched the epidemiology of Early-Onset Alzheimer's Disease (EOAD) for life insurance and critical illness insurance. Gutierrez and

Macdonald [2] discussed Adult Polycystic Kidney Disease (APKD), which are genetically dominant autosomal genes that lead to End-Stage Renal Disease (ESRD) or kidney failure. Gutierrez and Macdonald [2] proposed a critical illness (CI) insurance model and estimated the onset rates of ESRD and APKD using two studies. Other events leading to claims under CI policy were included in the model studied. Other critical illness studies are coronary heart disease and stroke by Macdonald et al., [3]. This part 1 study aims to develop a model that can assess the impact on insurance coverage of genetic information relevant to coronary heart disease and stroke. The study part II of Macdonald et al. [4] extends the model created in Part 1 to include other critical illnesses, such as cancer and renal failure, and describes several applications of the model.

In the insurance literature, several authors have reviewed the multi-state model in their writings. The Markov multi-state model first appeared by Amsler [5] and Hoem [6]. Haberman [7] discusses the solution to the multi-state model problem by utilizing a decrement table. In the following paper, Haberman [8] provides an alternative solution using the assumption of the Markov model, namely that there is a transition intensity in each status. In the other paper, Waters [9] compared the two approaches, namely FOIA and TIA (transition intensities approach), and concluded that TIA is better for a multi-state model. Haberman and Pitacco [10] discussed applying a multi-state model based on the Markov model in health insurance. The Markov multi-state model is used to calculate the intensity of the transition, the transition between statuses, and the premium on long-term care insurance (LTC) by Kusumawati and Gunardi [11]. For a comprehensive survey of the CI and LTC insurance actuarial models, see Pitacco [12].

Insurance that covers critical illness is different from health insurance. Health insurance helps cover costs needed while in hospital, such as doctor visits, hospital bills, and surgery. Meanwhile, critical illness insurance disburses a certain amount of cash when a person is diagnosed and is arranged by the customer for whatever needs he needs. In other words, the benefit of protection for critical illness is given directly to customers, not to hospitals or doctors. Customers have the full right to use the cash according to their daily needs. In this research, we will discuss the problems of critical illness, namely breast cancer, by forming a multi-state model.

Breast cancer occurs due to the abnormal growth of cells in the breast. Genetically inherited gene mutations cause abnormal growth. The gene mutation causes the formation of cancer, whether it is a benign or malignant cancer. The classification of benign and malignant cancers has been investigated using Regularized Logistic Regression with Adaptive Elastic Net [13]. The type of cancer also determines the success of chemotherapy. Chemotherapy can be the main alternative in cancer treatment, although the body's response to chemotherapy will vary. The treatment response was used as a reference in forming a multi-state model in this study.

2 Model Construction

The model in this study discusses the Markov process, which describes the critical illness insurance policy in each state for a continuous time. Critical cancer disease is modeled by several states, namely $\{S(t)\}_{t\in[0,T]}$ with S is a set whose members A is healthy or disease-free, B is early cancer, C is advanced cancer or cancer increase after chemo, and Y is dead because cancer. This condition is based on the response to treatment after chemotherapy. Transitions between statuses are shown in Figure 1. The treatment response of patients after chemotherapy is shown in Table 1. This model assumes that the first time patients come to the hospital for laboratory examinations are in-state B, which means they have cancer. Then the change in state B to C, Y, or back to A is obtained from the treatment response to chemotherapy. Sometimes there is no success in the chemotherapy process, so patients with cancer in-state B will move to state C as cancer grows, this is called progressive disease. The switch from B to A is called a complete response because the success of chemotherapy that causes cancer is no longer visible. Patients in-state C may also experience a complete response by returning to state A. Patients who died in states B and C were classified as cancer deaths. Sometimes, chemotherapy does not have a significant impact on cancer growth, so it does not change the state of cancer, this event is called a stable disease or partial response. Figure 1 shows the diagram of changes between states.

Table 1. Treatment Response

Status Change	Response
$B \to C$	Pregressive Disease
$C \to A$	Complete Response
$B \to A$	Complete Response
$B \to B$	Stable Disease / Partial Response
$C \to C$	Stable Disease / Partial Response

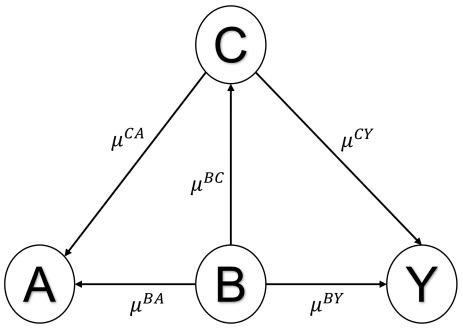

Figure 1. Compartment Status Diagram

3 Transition Probability

Let $x(x \geq 0)$ be the patient's age, and $S(t)$ is the state occupied by the policyholder at time t. If the policyholder is in

status i at age x, then the definition of the transition probability of the policyholder who is in status j at age $x+t$ is

$${}_tp_x^{ij} = P\left\{S\left(x+t\right)=j|S\left(x\right)=i\right\} \qquad t\in[0,T]\,,\ i,j\in S, i\neq j$$

The definition for the transition intensity μ^{ij} is as follows

$$\mu^{ij}\left(x\right)=\lim_{t\to 0}\left(\frac{{}_tp_x^{ij}}{t}\right) \quad t\in[0,T]\,,\ i,j\in S, i\neq j$$

If the policyholder remains in status i, meaning that he has not changed at age $x+t$, it is defined.

$${}_tp_x^{ii} = P\left\{S\left(x+t\right)=i|S\left(x\right)=i\right\} \qquad t\in[0,T]\,,\ S\left(x\right)=i$$

The transition probability from the multi-state model is the solution of Kolmogorov's forward differential equation, as in the research of Haberman and Pitacco [10]. The transition probability according to the model in this study (Figure 1) is

$$\begin{aligned}
\frac{d_t P_x^{BB}}{dx} &= -{}_tP_x^{BB}\left(\mu^{BA}+\mu^{BC}+\mu^{BY}\right) && (1)\\
\frac{d_t P_x^{CC}}{dx} &= -{}_tP_x^{CC}\left(\mu^{CA}+\mu^{CY}\right) && (2)\\
\frac{d_t P_x^{BC}}{dx} &= {}_tP_x^{BB}\mu^{BC}-{}_tP_x^{BC}(\mu^{CY}+\mu^{CA}) && (3)\\
\frac{d_t P_x^{BA}}{dx} &= {}_tP_x^{BB}\mu^{BA}+{}_tP_x^{BC}\mu^{CA} && (4)\\
\frac{d_t P_x^{CA}}{dx} &= {}_tP_x^{CC}\mu^{CA} && (5)\\
\frac{d_t P_x^{BY}}{dx} &= {}_tP_x^{BB}\mu^{BY}+{}_tP_x^{BC}\mu^{CY} && (6)\\
\frac{d_t P_x^{CY}}{dx} &= {}_tP_x^{CC}\mu^{CY} && (7)
\end{aligned}$$

The first step in this research is to determine the intensity of the transition based on the constructed model. Each patient represents the realization of the Markov chain X_x where x is the patient's age in the five states. Each patient's transition was observed, and the time the transition occurred. For each $i,j=A,B,C,Y$ model in Figure 1 obtained

$$\begin{aligned}
\log L\left(\mu_x^{ij}\right) &= \log L\left(\mu_x^{BA},\mu_x^{BC},\mu_x^{BY},\mu_x^{CA},\mu_x^{CY}\right)\\
&= \sum_{i,j\in S}\left(-\mu_x^{ij}t_i+n_{ij}\log\left(\mu_x^{ij}\right)\right)\\
&= -t_B\left(\mu_x^{BA}+\mu_x^{BC}+\mu_x^{BY}\right)\\
&\quad -t_C\left(\mu_x^{CA}+\mu_x^{CY}\right)+n_{BA}\log\mu_x^{BA}\\
&\quad +n_{BB}\left(\log\mu_x^{BA}+\log\mu_x^{BC}+\log\mu_x^{BY}\right)\\
&\quad +n_{BC}\log\mu_x^{BC}+n_{BY}\log\mu_x^{BY}\\
&\quad +n_{CA}\log\mu_x^{CA}+n_{CY}\log\mu_x^{CY}\\
&\quad +n_{CC}\left(\log\mu_x^{CA}+\log\mu_x^{CY}\right) \qquad (8)
\end{aligned}$$

where
t_B : the total time a person was in early cancer status (years)
t_C : total time a person was in advanced cancer status (years)
n_{ij} : the number of people transitioning from state i to state j

The solution of the following equation is sought to determine the estimator of the transition intensity.

$$\begin{aligned}
\frac{\partial\log L\left(\mu_x^{BA},\mu_x^{BC},\mu_x^{BY},\mu_x^{CA},\mu_x^{CY}\right)}{\partial\mu_x^{AX}} &= 0\\
-t_B+\frac{n_{BB}+n_{BA}}{\mu_x^{BA}} &= 0\\
\hat{\mu}_x^{BA} &= \frac{n_{BB}+n_{BA}}{t_B} \qquad (9)
\end{aligned}$$

In the same way, another transition intensity is obtained.

$$\hat{\mu}_x^{BC}=\frac{n_{BB}+n_{BC}}{t_B}, \qquad (10)$$

$$\hat{\mu}_x^{BY}=\frac{n_{BB}+n_{BY}}{t_B}, \qquad (11)$$

$$\hat{\mu}_x^{CA}=\frac{n_{CC}+n_{CA}}{t_C}, \qquad (12)$$

$$\hat{\mu}_x^{CY}=\frac{n_{CC}+n_{CY}}{t_C} \qquad (13)$$

The transition's intensity will be used to determine the value of the transition probability, which has been stated in the differential equations (1-7). Based on the conditions μ described in equations (9-13), the solution of the transition probability differential equations is expressed in the equation (14-20).

$$\begin{aligned}
{}_tP_x^{BB} &= e^{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}\right)t} && (14)\\
{}_tP_x^{CC} &= e^{-\left(\mu^{CA}+\mu^{CY}\right)t} && (15)\\
{}_tP_x^{BC} &= \frac{{}_tP_x^{BB}\mu^{BC}}{-\left(\mu^{CA}+\mu^{CY}\right)}\left(e^{-\left(\mu^{CA}+\mu^{CY}\right)t}-1\right) && (16)\\
{}_tP_x^{BA} &= \int_0^t\left({}_tP_x^{BB}\mu^{BA}+{}_tP_x^{BC}\mu^{CA}\right)dx && (17)\\
{}_tP_x^{CA} &= \frac{\mu^{CA}}{-\left(\mu^{CA}+\mu^{CY}\right)}\left(e^{-\left(\mu^{CA}+\mu^{CY}\right)t}-1\right) && (18)\\
{}_tP_x^{BY} &= \int_0^t\left({}_tP_x^{BB}\mu^{BY}+{}_tP_x^{BC}\mu^{CY}\right)dx && (19)\\
{}_tP_x^{CY} &= \frac{\mu^{CY}}{-\left(\mu^{CA}+\mu^{CY}\right)}\left(e^{-\left(\mu^{CA}+\mu^{CY}\right)t}-1\right) && (20)
\end{aligned}$$

4 Pure Premium Rate

Critical Illness (CI) coverage is usually combined with life insurance (endowment) to benefit sufferers or additional services. When serious illness occurs, the insurance company prepays the sum insured in case of death. In case of critical illness, the insurance company pays additional benefits for the sum insured in the end. Depending on the type of CI coverage, we can define different formulas for calculating the pure premium rate [14]. Based on the age period $(x, x+N)$, the integral formula of the pure premium is obtained by adding up the sub-integrals that are each defined in the sub-interval $(0,y_1],(y_1,y_2],\ldots,(y_{k+1},\ y_{k+2}),\ \ldots,\ (y_{n-1},N]$ where $y_{k+1}=x_{k+1}-x$ and with $y_0=0$, and $y_n=N$. Based on these conditions, the integral result can be obtained at the sub-interval (y_k,y_{k+1}).

4.1 Stand-Alone

Stand-Alone critical illness policy with a duration limit of n, where the amount of coverage is calculated at the time of one of the critical illnesses. Equation (21) is the insurance premium rate from state transfer from early cancer to advanced cancer (progressive disease).

$$\begin{aligned}\bar{A}^{(SA)}_{x:n} &= \sum_{k=0}^{n-1}\int_{y_k}^{y_{k+1}} {}_tP_x^{BB}\mu^{BC}(x+t)\,v^t dt \\ &= \mu_x^{BC}\left(\frac{e^{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)n}-1}{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)}\right) \quad (21)\end{aligned}$$

4.2 Additional-Benefit

Additional-Benefit critical illness policy for term life insurance with a duration limit of n, where the amount of coverage is paid at the time of a critical illness and will receive additional benefits if the policyholder dies of a critical illness before the end of the policy contract. The equation (22) calculates the premium from the initial cancer condition with additional benefits when dying from cancer before the end of the policy contract. While the equation (23) is the calculation of additional benefits after the patient progresses to an advanced cancer state and dies due to an advanced cancer stage while still on the policy contract.

$$\begin{aligned}\bar{A}^{(AB)}_{x:n} &= \sum_{k=0}^{n-1}\int_{y_k}^{y_{k+1}} \left(tP_x^{BB}\mu^{BY}(x+t)\,v^t\right)dt \\ &= \mu_x^{BY}\left(\frac{e^{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)n}-1}{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)}\right) \quad (22)\\ \bar{A}^{(AB)}_{x:n} &= \sum_{k=0}^{n-1}\int_{y_k}^{y_{k+1}} \left(tP_x^{CC}\mu^{CY}(x+t)\,v^t\right)dt \\ &= \mu_x^{CY}\left(\frac{e^{-\left(\mu^{CA}+\mu^{CY}+\nu\right)n}-1}{-\left(\mu^{CA}+\mu^{CY}+\nu\right)}\right) \quad (23)\end{aligned}$$

4.3 Endowment-Benefit

Endowment-Benefit critical illness policy with a duration limit of n, where the sum insured is paid at the time of critical illness and will receive additional benefits if the policyholder recovers before the end of the policy contract. In addition to the additional benefits offered by insurance due to death when exposed to cancer, the insurer can also add other benefits in the form of endowment life insurance. This additional benefit is provided when cancer patients have a complete response after chemotherapy. This insurance helps customers to be able to save and still get insurance benefits even though they are recovering from a critical illness. The calculation of this additional benefit is shown in equation (24) for patients who recover from early cancer and equation (25) for patients who recover from advanced cancer.

$$\begin{aligned}\bar{A}^{(EB)}_{x:n} &= \sum_{k=0}^{n-1}\int_{y_k}^{y_{k+1}} \left(tP_x^{BB}\mu^{BA}(x+t)\,v^t\right)dt \\ &= \mu_x^{BA}\left(\frac{e^{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)n}-1}{-\left(\mu^{BA}+\mu^{BC}+\mu^{BY}+\nu\right)}\right) \quad (24)\\ \bar{A}^{(EB)}_{x:n} &= \sum_{k=0}^{n-1}\int_{y_k}^{y_{k+1}} \left(tP_x^{CC}\mu^{CA}(x+t)\,v^t\right)dt \\ &= \mu_x^{CA}\left(\frac{e^{-\left(\mu^{CA}+\mu^{CY}+\nu\right)n}-1}{-\left(\mu^{CA}+\mu^{CY}+\nu\right)}\right) \quad (25)\end{aligned}$$

5 Case Study

In this section, we will conduct a case study using data for breast cancer patients at Dr. Sardjito Hospital Yogyakarta. This study is to form a critical illness insurance model in Indonesia using the continuous-time multi-state Markov model assuming constant transition intensity and stationary Markov process and calculating the premium from critical illness insurance for certain benefits. To estimate the parameters of intensity and probability of transition, data representing the number of people transitioning from one state to another is needed per unit of time.

We use survival data taken from patient health records of as many as 130 patients at Tulip, Dr.Sardjito Hospital, and determine the observation period from July 2018 to April 2021. This data has been used in previous research [15]. Information obtained is the date of birth, initial examination, the date of response status after chemotherapy, and the date of death. Based on the data obtained, the patients' status consisted of free of disease, early cancer, advanced cancer, and death from cancer. The transfer of patient status is determined based on the treatment response, as shown in Table 1. The flow of state transfer is depicted in Figure 1.

5.1 Transition Intensity Estimation

The patient's behavior is observed during the observation period. The data were classified according to the age group of observation. The number of patients who transitioned between states was calculated based on the classification of observational age groups. The calculation results can be seen in the Tables 2 and 3 below.

Table 2. Number of transitions by age interval and type of transition (1)

Age intervals	n_{AA}	n_{BB}	n_{CC}	n_{BA}
30-39	4	1	0	5
40-49	28	10	5	34
50-59	17	7	4	28
60-69	5	3	6	10
70-79	2	1	0	3

The Tables 2 and 3 show that the most patients who transitioned from early cancer to healthy were 34 people aged 40

Table 3. Number of transitions by age interval and type of transition (2)

Age intervals	n_{BC}	n_{CA}	n_{BY}	n_{CY}
30-39	1	0	0	1
40-49	14	1	5	8
50-59	14	3	6	5
60-69	8	1	2	1
70-79	1	0	1	1

to 49 years. Otherwise, the few who transitioned from early cancer to healthy were people aged 70 to 79 years with 3 people. These two numbers represent the largest number resulting from the transition of the patient's condition in each age group. From these data, it can be seen that chemotherapy positively impacts the patient's recovery.

The length of time the patient faces the risk of moving to another state is calculated based on the difference between the transition date and the first date in the previous state. If a patient is newly diagnosed with cancer, the time period is calculated from the first time the patient performs a lab examination. The total transition time from one state to another can be seen in the Table 4. It can be seen that the most time spent in the age interval is at the age of 40 to 49 years. The estimation of transition intensity parameters for the age interval using equations (9) and equation group (10) can be seen in the Table 5.

Table 4. Total transition time by age interval and transition type

Age intervals	t_A	t_B	t_C
30-39	3,1595	3,5893	0,2793
40-49	30,5763	32,6434	9,1910
50-59	27,5838	34,4422	8,2190
60-69	9,5250	11,3018	6,9295
70-79	3,2991	2,7789	0,4600

Table 5. The estimated value of the transition intensity for each age interval

Age interval	μ_{BY}	μ_{BA}	μ_{CA}	μ_{BC}	μ_{CY}
30-39	0,279	1,672	0,000	0,557	3,581
40-49	0,460	1,348	0,653	0,735	1,414
50-59	0,377	1,016	0,852	0,610	1,095
60-69	0,442	1,150	1,010	0,973	1,010
70-79	0,720	1,439	0,000	0,720	2,174

For example, in the age range of 50-59, the intensity of the transition from early cancer to advanced cancer after chemotherapy was 0.6097, which means that the rate of change in a person's status from an early cancer patient who progressed to advanced cancer patient was 0,6097. The transition intensity from cancer patients, either early or advanced to dying from cancer, is 0,3774 and 1,0950, respectively. At the same time, the transition intensity from early or advanced cancer patients who returned to health is 1,0162 and 0,8517, respectively. This interpretation also applies to other age intervals.

5.2 Transition Probability Estimation

The transition probability estimation is obtained as in the equation (14-20). If we take $t = 1$, then the transition probability values for the five age groups are obtained in the Tables 6 and 7. It can be seen how big the chance of someone changing state is based on the age interval. The greatest opportunity to change status from advanced cancer to dead is because advanced cancer occurs from age 30 to age 39. The lowest probability of switching states is the state from advanced cancer to cure at 30 to 39 years and the age of 70 to 79 years with a probability of zero. This means that it is doubtful that patients with advanced cancer can be cured. Likewise, other transitions can be seen in Tables 6 and 7.

Table 6. Transition probability $(x, x+1)$ for each age interval (1)

Age interval	P_x^{AA}	P_x^{BB}	P_x^{CC}	P_x^{BA}
30-39	0,058	0,082	0,028	0,045
40-49	0,127	0,079	0,127	0,045
50-59	0,196	0,135	0,143	0,068
60-69	0,207	0,077	0,133	0,045
70-79	0,220	0,056	0,114	0,042

Table 7. Transition probability $(x, x+1)$ for each age interval (2)

Age intervals	P_x^{BC}	P_x^{CA}	P_x^{BY}	P_x^{CY}
30-39	0,012	0,000	0,906	0,972
40-49	0,024	0,035	0,897	0,598
50-59	0,036	0,060	0,829	0,482
60-69	0,032	0,068	0,891	0,434
70-79	0,017	0,000	0,927	0,886

5.3 Premium Calculation

Equations (21)-(25) are used in the calculation of premiums with different policies, can be a stand-alone policy, or a policy with additional benefits and endowment benefits.

1. Stand-Alone
   In stand-alone policies, benefits are only provided when there is an increase in critical illness, where cancer patients are first diagnosed in state B and experience an increase in cancer severity to state C after chemotherapy. After going through the calculations, the premium obtained from a stand-alone policy with the assumption that the coverage period is one year and an interest rate of 5%, along with the premium earned by age group, the results are shown in Table 8.

   Table 8 shows that premiums fluctuate by age group. The largest premium is in the age range of 60-69 with 34,5%, and the smallest is in the age range of 30-39 with 20%. The amount of insurance premium, in this case, can be obtained by multiplying the result of the premium percentage by the unit of the benefit obtained within one year.

2. Additional-Benefit
   In the additional benefit policy, the benefit is given when

Table 8. Stand-alone policy premium for one year

Age intervals	$\bar{A}_{x:n}^{(SA)}$
30-39	0,20099140
40-49	0,26236175
50-59	0,25883888
60-69	0,34486346
70-79	0,23259518

the status is critically ill, and the additional benefit is given when the person dies due to a critical illness suffered during the policy period. Additional benefit policy premiums with a coverage period of one year with an interest rate of 5% for the age group are shown in Tables 9 and 10.

Table 9. Additional-benefit policy premium for one year from state B to state Y

Age intervals	$\bar{A}_{x:n}^{(AB)}$
30-39	0,10049570
40-49	0,16397609
50-59	0,16023359
60-69	0,15675612
70-79	0,23259518

Based on the table 9, the highest premium calculation is in the age range of 70-79 years, which is 23.3%, and the lowest premium is at the age of 30-39 years, at 10%. This premium is paid when the customer is in state B and wants additional benefits if the patient dies of cancer during the policy agreement period at any time.

Table 10. Additional-benefit policy premium for one year from state C to state Y

Age intervals	$\bar{A}_{x:n}^{(AB)}$
30-39	0,96010127
40-49	0,58764406
50-59	0,47394931
60-69	0,42637697
70-79	0,87178674

Based on Table 10, the premium calculation shows a value that tends to decrease until the age of 69 years and increases after that. The premium value obtained is very high at the age of 30-39 by 96% and at the age of 70-79 by 87%. Compared to the additional benefits in state B, the additional premium in state C is much larger. It is reasonable because in state C, cancer has become more severe and prone to death.

3. Endowment-Benefit
In an endowment-benefit policy, additional benefits are provided when recovering from cancer within the policy's term. The state of cure from cancer is obtained when the patient has a complete response after chemotherapy. The calculation of the endowment benefit premium with an insurance period of 1 year with an interest rate of 5% can be seen in table 11 and table 12.

Table 11. Endowment-benefit policy premium for one year from state B to state A

Age intervals	$\bar{A}_{x:n}^{(EB)}$
30-39	0,60297420
40-49	0,48099654
50-59	0,43139813
60-69	0,40756591
70-79	0,46519036

The premium calculation in Table 11 tends to decrease, except for an increase in the age group of 69 to 70 years. The highest premium is in the age range of 30-39 years at 60.3%. In other age ranges, premiums range from 40% to 48%. The premium calculation in Table 12 tends to increase with increasing age from 40 to 69. In this endowment benefit premium calculation, there are zero values in the age range of 30-39 and 70-79. This situation is caused by no data on patients who remain in state C and move to state A, so the transition intensity data is zero.

Table 12. Endowment-benefit policy premium for one year from state C to state A

Age intervals	$\bar{A}_{x:n}^{(EB)}$
30-39	0
40-49	0,27122034
50-59	0,36862724
60-69	0,42637697
70-79	0

6 Conclusions

The formulas for calculating pure premium rates are obtained from the constructed model. The application of this model requires medical data from the hospital. The data used are medical records of breast cancer patients from the "TULIP" Installation of Dr. Sardjito Hospital Yogyakarta. Researchers collaborate with the hospital to record data for each patient from the start of treatment. Starting with the medical record data of each cancer patient collected by the Data Bank Hospital, the data is processed to obtain information according to the model created. The application of the model using hospital data is shown in the case study. The premium generated in this study is assumed to only depend on the number and time of state transfer data.

Based on the calculation formula for each insurance policy with an interest rate of 5%, various nominal premiums have been discussed in this case study. In stand-alone policies, the premium paid ranges from 20% to 34.5% of the benefit. In an additional benefit policy for early cancer, the premium value is 10% to 23.3%. Meanwhile, the premium value for advanced cancer is higher, from 42.6% to 96%. In an early cancer endowment benefit policy, the premium value is between 40.8% to 60.3%. Whereas in patients with advanced cancer, a smaller premium is obtained, which is between 27.1% to 42.6%. However, this value cannot be known from the data studied at the

age of 30-39 and 70-79.

Calculating premiums from various policies that can be offered have rational values, and there are also unreasonable values. These unreasonable values can be caused by the number of patients experiencing the transition being too few or even nonexistent in a specific age group. In the case of insurance that we often know in the field, the premium paid increases with age. However, this is not always the case based on the data in this model. This insurance model can be an alternative to a more accurate insurance calculation based on the incidence of displacement of critical patients, especially breast cancer patients.

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CONTINUING REVIEW APPROVAL OF APPROVAL

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Title of the Research Protocol	:	Analisis Efek Samping Kemoterapi, Faktor Resiko yang Memprediksi Kejadian Efek Samping, Serta Pengaruhnya Terhadap Kesintasan dan Kualitas Hidup Penderita Kanker Payudara: Studi Kohort Prospektif
Document(s) Approved and version	:	1. Study Protocol version 3.0 Januari 2020 2. Information for Subjects version 3.0 Januari 2020 3. Informed consent form version 3.0 Januari 2020
Principle Investigator	:	dr. Susanna Hilda Hutajulu, Ph.D., Sp.PD-KHOM.
Participating Investigator(s)	:	1. dr. Johan Kurnianda, Sp.PD-KHOM. 2. dr. Ibnu Purwanto, Sp.PD-KHOM. 3. dr. Kartika Widayati, Sp.PD-KHOM. 4. dr. Mardiah Suci Hardiyanti, Ph.D., Sp.PD-KHOM. 5. dr. Siswi Oktariani, Sp.PD. 6. dr. Vita Yanti Anggraeni, M.Sc., Ph.D., Sp.PD., Sp.JP. 7. dr. Anggoro Budi Hartopo, M.Sc., Ph.D., Sp.PD., Sp.JP. 8. dr. Hasanah Mumpuni, Sp.PD., Sp.JP(K). 9. Prof. Dr. dr. Budi Yuli Setianto, Sp.PD-KKV., Sp.JP(K). 10. dr. Yudiyanta, Sp.S(K). 11. Dr. dr. Irianiwati W., Sp.PA(K). 12. Prof. Lee Soo Chin 13. Dr. Matthew Allsop, B.Sc., Ph.D. 14. Prof. Dra. Yayi Suryo Prabandari, M.Si., Ph.D. 15. M. Ivan Ariful Fathoni, S.Si., M.Si. 16. Dian Caturini S., M.Sc. 17. Riani Witaningrum, M.Sc., G.TH. 18. Sunarti, A.Md. 19. Sri Mardilah Wuryani, A.Md. 20. dr. Aras Amila Husna 21. dr. Irfan Haris 22. Norma Dewi Suryani, SKM. 23. Betrix Rifana, SKM. 24. Fitrina Mahardani K., SKM., MPH. 25. Syafriani, SKM., MPH. 26. dr. Agus Jati Sunggoro, Sp.PD. 27. dr. Herindita Puspitaningtyas 28. dr. Yufi Kartika Astari 29. dr. Brilliant Winoma Jhundy 30. dr. Arief Gusnanto
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Institution(s)/place(s) of research	:	Rumah Sakit Umum Pusat Dr. Sardjito Yogyakarta, Instalasi Catatan Medik, Departemen Bedah, Instalasi Tulip, Departemen Radioterapi, Departemen Patologi Anatomi, Departemen Kardiologi dan Kedokteran Vaskular, Instalasi Jantung

The Medical and Health Research Ethics Committee (MHREC) states that the document above meets the ethical principle outlined in the International and National Guidelines on ethical standards and procedures for researches with human beings.

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- ☑ Report of any serious adverse events (SAE)
- ☑ Final report upon the completion of the study

Dr. dr. Eti Nurwening Sholikhah, M.Kes., M.Med.Ed.
Panel's vice chairperson

dr. Rizka Humardewayanti A., Sp.PD-KPTI.
Panel's secretary

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