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CONSTRUCTION OF INDONESIA MORBIDITY TABLE FOR GENITOURINARY SYSTEM-RELATED DISEASES TO FACILITATE INDONESIA'S ECONOMIC EXPANSION

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ABSTRACT

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The disease of the genitourinary system is one of the most common diseases in Indonesia. The disease shows some risk, especially in health and economic aspect. To overcome the risk posed by disease of the genitourinary system, a morbidity table can be used to reduce the number of people infected by the disease, and in this research, morbidity table based on sample data of BPJS Kesehatan from 2015 to 2016 will be constructed. Data processing starts with obtaining the empirical probability value of the disease of the genitourinary system. Then, the result obtained was interpolated in numerous preferences of methods. After the best interpolation model was known, the extrapolation process was run at an age range from age 80 to age 85 using Whittaker-Henderson smoothing method. The age range chosen is due to the fact that for ages over 80 years, the number of exposures is minimal, which can affect the number of claims in that age group. Extrapolation is extended up to the age of 85 years because the Morbidity Table for Critical Illness sets the age of 85 years as the upper limit for extrapolation. The model derived from interpolating age groups with a knot shows the highest R-square value, making it the most optimal model. It shows that Indonesians' probability to contract the disease is increasing significantly from about age 25 until around age 65, and the probability slowly declines after age 65. This result can be used as a reference by the Government of Indonesia to produce regulations leading to health protection for all citizens of Indonesia, especially for those who are classified as the labor force. Health protection provided by the government should improve welfare in Indonesian society. Moreover, the regulation should protect the productivity of the manpower and raise Indonesia's Gross Domestic Product (GDP). BPJS Kesehatan can also use this predicted morbidity table to determine the right contribution fee. Hence, the contribution can be beneficial to pay any expense of the patient who contracted the disease, but on the other hand, not sending BPJS Kesehatan into bankruptcy. All of abovementioned efforts have one bold intention—to support Indonesia's economic expansion as Indonesia aims to reach Golden Indonesia Vision by 2045.

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1. INTRODUCTION

The genitourinary system consists of two organs system: urinary system and reproduction system, while kidney is one of main organ in the genitourinary system [1]. Disease related to genitourinary system is such a concerning thing, because as the end of 2022, Indonesians were shocked by significant increase of acute kidney injury cases reported by Ministry of Health of the Republic of Indonesia. It is reported that most casualties of acute kidney injury came from cough and flu syrup consumers. It is also evident that per November 2022, more than 300 cases of acute kidney injury have been reported and the death toll related to the disease reached almost 200 [2]. Aside from the ministry's report, research has found that Indonesian dietary habit is strongly dependent on sugar and salt, and it has been proven that overconsumption of sugar and salt would gradually damaging human's kidney [3]–[5]. According to historical data of BPJS Kesehatan from 2015 to 2016, it is shown that one of most reported diseases are related to genitourinary system. It is known that diseases related to genitourinary system make more than 6% of existent BPJS Kesehatan claim along the period and among all possible causes of claim submissions at BPJS Kesehatan, it indicates a significant percentage as the number of patients of genitourinary-related diseases is the largest among insured population with other disease based on BPJS Kesehatan historical data. It is important to note that this kind of phenomenon strongly influences BPJS Kesehatan's funding system, as it is widely well-known that healing process of disease related to genitourinary system spend huge amounts of resources. We also need to take note that diseases related to the genitourinary system are able to affect individuals of all group of ages. Past research even discovered that unborn infants also have possibility to contact diseases related to the genitourinary system [6]. Therefore, in fact, every participant of BPJS Kesehatan plays part in every emerging financial risk linked to handling and/or healing process cost of diseases related to the genitourinary system faced by BPJS Kesehatan.

The high financing risk can be observed, among other things, through the frequency of genitourinary system-related diseases for each age group. This frequency can be measured by the probability of genitourinary system-related diseases happening that are summarized in a morbidity table. Morbidity itself signifies the occurrence of a change in physiological status from health to illness and vice versa of a community [7], [8]. This means that the morbidity table for critical diseases contains information about the comparison of an individual's likelihood of getting sick and/or being exposed to the risk of critical diseases at each age (or age group) with individuals who have or have not been sick and/or exposed to the risk of critical diseases at each age (or age group). A specific morbidity table for critical diseases is expected to depict the likelihood of individuals at risk of these diseases. Furthermore, the role of the morbidity table for one of the critical diseases, which is genitourinary, is essential in the process of BPJS Kesehatan's premium pricing. This is intended to ensure that the premium amount for BPJS Kesehatan remains sufficient to finance patients with genitourinary system-related diseases, without overburdening the financing mechanism of BPJS Kesehatan for the treatment of diseases unrelated to the genitourinary system. Moreover, the effect of morbidity is more distinct in a country that is undergoing economic expansion and is high-income [9]. Based on the classification prepared by the World Bank, Indonesia is not currently classified as a high-income country [10], but Indonesia meets the criteria for being considered a country experiencing economic expansion because, a country experiencing economic expansion must show a long-term increase in national income, with national income representing the meaning of Gross Domestic Product (GDP) [11]. Furthermore, it is widely known that economic expansion in a country is determined by its economic growth [12]. Therefore, Indonesia can be said to be experiencing economic expansion because, since 2015, data reported by the World Bank consistently shows that Indonesia has been able to record GDP growth, although there was a decline in GDP during the peak of the COVID-19 pandemic in Indonesia. Moreover, according to the World Bank, Indonesia's economic growth outside the peak of the COVID-19 pandemic has consistently shown positive results since 1999 [13], [14]. On the other hand, Indonesia is predicted to develop into a high-income country by 2030 [15]. A country experiencing economic expansion depends on labor productivity, with the manpower has some probability to be unproductive due to various causes. One of the causes is exposure to various diseases, including diseases related to the genitourinary system. Hence, to facilitate Indonesia's transition to a high-income country, the authorities should use a morbidity table for genitourinary diseases as an effort to protect the manpower from the threat of genitourinary system-related diseases. Consequently, labor productivity can be maintained to support the ongoing economic expansion.

Morbidity table for specified case of genitourinary system can also be used as consideration in the making of health policy by the Minister of Health of the Republic of Indonesia. For all mentioned reasons, in this research, we will construct Indonesia morbidity table for specified case of genitourinary system based on BPJS Kesehatan's historical data.

2. RESEARCH METHODS

2.1 Macroeconomy

The construction of mortality table is closely related to the behavior of Indonesian people. Many health factors are influenced by human lifestyle, such as eating too much fast food will lead to obesity, eating too much sugary food will cause diabetes, and food that is not kept clean is more likely to be exposed to bacteria and viruses. Quality of Indonesia's human resource can contribute to deterioration of Indonesian's health condition and increasing the risk of exposure to diseases. This will affect Indonesia's macroeconomic condition. Based on duration, problems in macroeconomics are divided into two, namely short-term problems, such as inflation and employment, and long-term problems, such as increasing Gross Domestic Product (GDP) and economic growth in Indonesia. Long-term problems are part of macroeconomics' problems, for example population growth, inequal income distribution, and poverty [16].

Modern economists define inflation as a general increase in the purchasing power of money, which means that it takes more money to buy the same goods and services. Inflation occurs when the price of goods and services are generally increasing, and there are two main causes of inflation: escalation in purchasing power and production costs. When purchasing power increases, people have more money to spend, which can drive up demand for goods and services. This can lead to businesses raising their prices to meet the increased demand, causing further fuel inflation. However, this should not frightened government because the purchasing power of Indonesian people are also high. On the other hand, the increase in production cost happens because the price of raw material and service fee are escalating. The government needs to hold the production cost by aiding the cost of raw material. Besides that, the government must be aware of the inflation rate of a country. If the inflation rate is over 10%, it will most likely decrease Indonesian's income and welfare [16], [17].

Another macroeconomy's short-term problem is employment. There are many employment issues that need to be addressed by the government, namely: the large number of forced unemployed, the imbalance between the labor force and the non-labor force, and the labor force participation rate. Those macroeconomy issues will affect Indonesia's macroeconomy and will boost mortality rate of genitourinary disease in Indonesia if the government is not aware about the problem [16].

Gross Domestic Product (GDP) is a measure of the total amount of goods and services produced by economic agents through various economic activities in a country at a given time. On the other hand, national income is a part of GDP that is transformed into various incomes in society, such as wages for workers and profits for capital owners. The small amount of GDP and national income is long-term problems of macroeconomy because of many factors and government need to pay attention to increasing GDP and national income, such as investment, economic development, and government budget are all important issues that need to be considered by government [16].

This mortality table will help macroeconomics' problem. One of the issues arises when macroeconomics condition in Indonesia is below average, as this will significantly impacting economic preference, when people tend to opt for lower-quality goods at cheaper price, rather than higher-quality goods but more expensive. One of the goods that people look for cheaper price is food, and this will reduce the quality of health of the Indonesian people, since lower-quality food's nutritional value is extremely questionable [18]. Moreover, many Indonesians prioritize purchasing cigarette over some quality food, leading to malnutrition among their children [19]. Therefore, the Ministry of Economy needs to provide subsidy policies for basic commodities so that the health of the Indonesian people improves [18], [19]. The government with Ministry of Health can observe the age of Indonesian people who make claims due to the genitourinary system, so Ministry of Health can make a regulation that decrease people who can affect to genitourinary system problem. When the number of people who get genitourinary problem decreases, people can carry out economic activities more optimally. In addition, the Ministry of Health can issue regulations or regulations to prevent food ingredients that have the potential to trigger diseases in the genitourinary system and/or conduct socialization to spread awareness among the community about the importance of preventing genitourinary system diseases. Such movement from Ministry of Health should increase quantity and quality of labor in Indonesia, thus the national income should also be increased, and Indonesia's GDP are getting higher [16].

2.2 Interpolation

The most common curve fitting techniques used in everyday life are regression and interpolation techniques. Regression can be used if data have a high error rate, so that not all points need to be passed through by the curve. Interpolation can be used when need small error rate, so that all points need to be passed through by the curve [20].

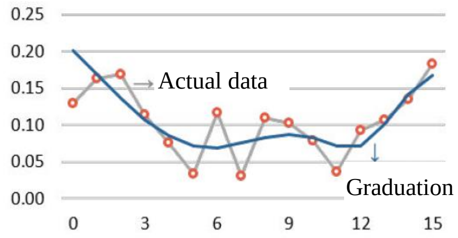

Figure 1 Interpolation Result, with the x-axis and y-axis Respectively Represent the Age of the Claim and the Probability of Something Happening.

Interpolation is a method that is commonly used to estimate value between data. To estimate the value, polynomial is the most used with the formula:

$$f(x) = a_0 + a_1 x + a_2 x^2 + \cdots + a_n x^n \tag{1}$$

with predictor x, response $f(x)$, and predictor's coefficient $(a_1, \ldots, a_n)$ [20], [21].

In general, to decide the model for n data, polynomial with $n-1$ degree, such like data with two values can be modeled with linear polynomial. However, in practice, this is not always the case, so another method is needed to make the best polynomial model. The most common method in this case is spline interpolation. This method is modelling data with a lower degree of polynomial by separating data into several groups. Cubic spline method is spline interpolation for every group with cubic polynomial. This method uses an approach using connecting polynomials with spline functions. According to [22], the equation used for each group is

$$f_i(x) = a_i x^3 + b_i x^2 + c_i x^3 + d_i \tag{2}$$

Definition 1. *Spline function is cubic polynomial function which is continuous while the first and second derivative are continuous too.* [22]

For every $n+1$ data, there will be n interval and $4n$ variable that needs to search. The requirement to get the variable value are: [20]

1. The values of the function at each interior knot must be equal and applicable:
$$a_{i-1}x_{i-1}^3 + b_{i-1}x_{i-1}^2 + c_{i-1}x_{i-1} + d_{i-1} = f(x_{i-1}) \tag{3}$$
$$a_i x_i^3 + b_i x_i^2 + c_i x_i + d_i = f(x_{i-1}) \tag{4}$$
for $i = 2,3,\ldots,n$. Because only interior knots are used, so in **Equation (3)** and **Equation (4)** each provide $n-1$ equation for a total of $2n-2$ condition.

2. The first and last equation should in the first point and last point, so there will be another two equations:
$$a_1 x_0^3 + b_1 x_0^2 + c_1 x_0 + d_1 = f(x_0) \tag{5}$$
$$a_n x_n^3 + b_n x_n^2 + c_n x_n + d_n = f(x_n) \tag{6}$$
Therefore, there will be $2n$ equations.

3. The first derivative from interior knots value should be same. If the first derivative from polynomial is
$$\frac{d}{dx} f_i(x) = 3a_i x^2 + 2b_i x + c_i \tag{7}$$
Therefore, for every condition, with $n-1$ equation, this condition will apply:

$$3a_{i-1}x_{i-1}^2 + 2b_{i-1}x_{i-1} + c_{i-1} = 3a_i x_{i-1}^2 + 2b_i x_{i-1} + c_i \quad (8)$$

4. The second derivative from interior knots value should be same. If the second derivative from polynomial is

$$\frac{d}{dx} f_i(x) = 6a_i x + 2b_i \quad (9)$$

then, for every condition, with $n-1$ equation, this condition will apply:

$$6a_{i-1}x_{i-1} + 2b_{i-1} = 6a_i x_{i-1} + 2b_i \quad (10)$$

5. The second derivative value should be zero in starting point and end point, so that condition below applies.

$$6a_1 x_0 + 2b_1 = 0 \quad (11)$$

Definition 2. *Knots are the meeting points between two splines. Interior knots are knots that are not at the end of the graph.* [20]

2.3 Extrapolation

In general, the data available to compile a morbidity table is not complete. Hence, extrapolation method is required to determine mortality value. To gain more precise understanding about extrapolation, below is the illustration of extrapolation result presented by [22].

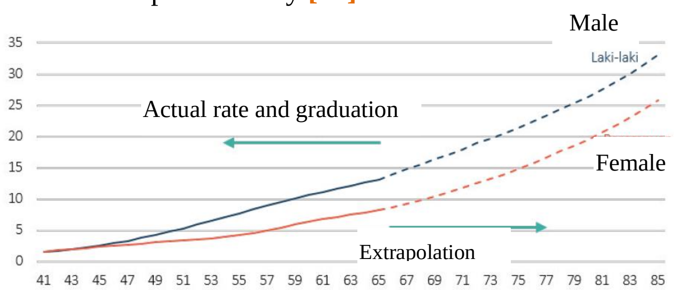

Figure 2 Illustration of Extrapolation Result, with the x-axis and y-axis Respectively Represent the age of the Claim and Claim Amount.

Extrapolation is done by analyzing data's trend. Then, the value from incomplete data will be estimated with extrapolation method.

One of the most common extrapolation methods is Whittaker-Henderson. According to [23], for n data observation $\{y_1, y_2, \dots, y_n\}$, there will be a real positive number, called λ, which shows tradeoff between fidelity and smoothness, with Δx_j show the fidelity of j-th data, $\Delta^2 x_j$ show the smoothness of j-th data, p is positive integers that is smaller than n, and λ is forward difference operator. Then, value of the sequence $\{x_1, x_2, \dots, x_n\}$ can be searched by minimize function:

$$\lambda \sum_{j=1}^{n} (y_j - x_j)^2 + \sum_{j=1}^{n-p} (\Delta^p x_j)^2 \quad (12)$$

for

$$\Delta x_j = x_{j+1} - x_j, \quad (13)$$

$$\Delta^2 x_j = \Delta(\Delta x_j) = x_{j+2} - 2x_{j+1} + x_j. \quad (14)$$

The value of λ will affect with the convergence's estimate value. If λ approaches infinity, then the estimated value will converge to the real data. Meanwhile, if λ approaches zero, the estimated smoothness will converge to $p-1$ degrees of polynomial [23][24].

2.4 Probability Calculation

According to [25], probability is every condition that can happen in one experiment by means of a set of real numbers between zero and one. If the probability value approaches zero, then the probability of a condition is most unlikely to happen. Probability of an experiment is

$$\Pr(A) = \frac{n(A)}{N}, \tag{15}$$

with $\Pr(A)$ is the probability of event A, $n(A)$ is the number of events that occur in a random experiment A, and N is the set of all possible events in a random experiment. This probability calculation is one of the most common methods that is often used by the public to estimate something that will happen. As an illustration, suppose at the age of 12, there were 4 claims that occurred with a lot of exposure of 38,282 people, so the probability of Indonesian people at the age of 12 make the claim is 4 divided 38,282, and the result is 0.000104488 [25].

The value in the morbidity table can be searched with probability calculation concept [26]. Based on previous illustration, the value of the probability is obtained from the value of the number of claims, in this case the number of policyholders who made claims, divided by the number of exposures, in this case the number of BPJS Kesehatan participants.

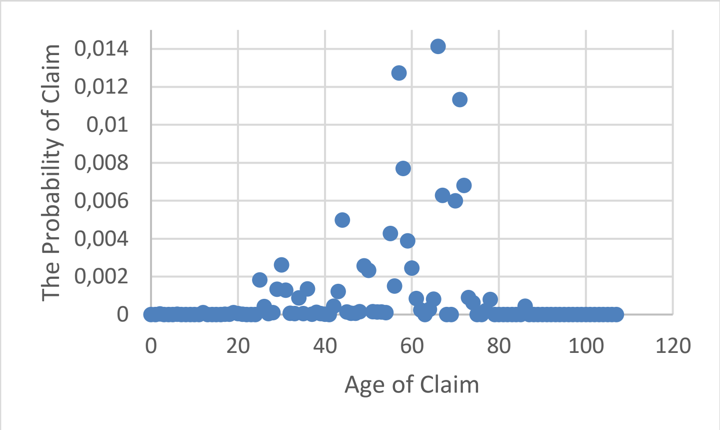

Figure 3 Morbidity value of Indonesian people in every age, with the x-axis and y-axis represent the age of claim and the probability of claim, respectively.

Figure 3 shows morbidity value in every age from Indonesian people who suffers from genitourinary system disease at 2015-2016 [26]. In data for ages 80 and over, the data is always zero. The lack of available data requires extrapolation to be performed to find the probability value based on the trends of previous ages [22].

After data for ages 80 and over is extrapolated and the model of morbidity because of genitourinary system disease is constructed, to determine the goodness of the model, we need to count coefficient of determination. Coefficient of determination, called R-square, is a measurement to know the performance of model in representing data. The value of coefficient of determination is show proportion all of respond's variability from the model, that be count as

$$R^2 = 1 - \frac{SSE}{SST}. \tag{16}$$

where SSE is the error sum of squares and SST is the total corrected sum of squares. The value of coefficient of determination is a real number between zero and one, for R-square's value approaches zero mean the model does not model the event, and R-square's value approaches to one mean the model models the event perfectly. When the value of coefficient of determination is bigger, the model is better in explaining the available data [26], [27].

2.5 Genitourinary System

The word "genitourinary" is divided into two words, namely "urinary", which means "excretory system", and "genito", which means "genital and reproductive system". Genitourinary is an organ in the human body which contains genital, reproductive and excretory system, and grouped as genitourinary because of its closeness in human body [1].

In the human body, the urinary system is needed to control human body in homeostasis condition, a condition that human body in constant condition and can work properly [28], by control composition and volume from blood. The urinary system is made up of two kidneys, two ureters, one urinary bladder, and one urethra. In every kidney, excretes urine through ureter. The urine is stored in the urinary bladder and finally expelled from the body through the urethra [28].

The genital and reproductive system functions to perform sexual reproduction. The genital systems of men and women are different, which male have penis and women have vagina. For men, reproduction system is made up of penis, testes, epididymis, ductus deferens, seminal vesicles, ejaculatory duct, prostate gland, Cowper's Gland, and urethra. However, women reproduction system consists of mons pubis, labia majora, labia minora, clitoris, urinary meatus, vaginal orifice, Bartholin's Gland, perineum, uterus, fallopian tube, ovarium, and vagina [28].

Genitourinary system problem is one of the most common problems suffered by Indonesian people. According to [29], as of March 2023, 739,000 Indonesians have had chronic kidney disease, with the age range of 65-74 years and 15-24 years having the largest and smallest populations of chronic kidney disease sufferers. Based on Eva Susanti, PT2PTM's director, until 2019 the death caused by chronic kidney disease is eleventh most deathly in the world and Indonesia. Susanti also said that chronic kidney disease is one of the deathliest diseases in Indonesia after heart disease, stroke, Chronic Obstructive Pulmonary Disease (COPD), and diabetes. This problem is strengthened by report in March 2022 that dr. Theresia Sandra Diah Ratih, Coordinator of Cardiovascular Disease Substances, Directorate of Prevention and Control of Non-Communicable Diseases, Ministry of Health, is estimated that death rate because of kidney disease is up to 42 thousand people every year [30]. The same source also reported that BPJS Kesehatan is spent up to 2.2 billion Indonesian Rupiah for 1.7 million kidney failure patients. Therefore, the mortality table is very important to make as a guideline for Ministry of Health to make some regulation in the future, both preventive measures and treatment measures for patients with genitourinary system diseases in Indonesia so the problem at genitourinary system can be prevented and managed well.

3. RESULTS AND DISCUSSION

3.1 Algorithm to Construct Morbidity Table for Genitourinary System-Related Diseases

Algorithm for constructing a morbidity table for genitourinary system-related disease is as follows:

1. Input sample data of BPJS Kesehatan.
2. For each claim data, check if the claim data matches with policyholders' data.
   a. If the claim data does not match with policy holders' data, delete claim data.
   b. If the claim data matches with policy holders' data, calculate the age of policyholders when claim occurred.
3. Calculate the empirical morbidity table.
4. Categorizing age of BPJS Kesehatan policyholders with certain interval. Then, do steps 2 and 3 for each group.
5. Do interpolation of data with preference of using knot or not for results from 3 and 4.
6. Choose the best model with the criterion of R-square.
7. Extrapolation with the best model for age group which has a small number of exposures.
8. Create morbidity table with model from 7.

3.2 Empirical Morbidity Table

The morbidity table is generally used in the field of insurance to calculate the individual's risk of suffering a specific disease or condition. In this research, a morbidity table for the genitourinary system disease will be calculated. Before performing interpolation and extrapolation, it is necessary to calculate the empirical probability of someone suffering system diseases at certain age. Empirical probability is the probability obtained based on actual data or observations of an event or experiment. The probability of an individual suffering system diseases at age x (x could be point or interval) calculated with

$$I_x = \frac{\theta_x}{E_x},$$

where θ_x denotes total of insurance claim at age (or age group) x and E_x denotes total of exposure at age (or age group) x.

Below are empirical morbidity table at age x and interval x, with interval being ten years follows [26]. The graph of empirical morbidity table at age in Figure 4 shows that morbidity rate from age 0 to 24 is close to zero. It also shows that people aged 0 to 24 rarely contract genitourinary system-related disease. As age increases, the morbidity rate develops with its peak at the age 66.

Table 1 Empirical Morbidity Table at Age.

Age	I_x	Age	I_x	Age	I_x	Age	I_x
0	0.000000000	**23**	0.000000000	**46**	0.000069432	**69**	0.000000000
1	0.000000000	**24**	0.000000000	**47**	0.000073833	**70**	0.006007925
2	0.000045239	**25**	0.001832400	**48**	0.000161753	**71**	0.011333794
3	0.000000000	**26**	0.000425852	**49**	0.002571036	**72**	0.006814608
4	0.000000000	**27**	0.000050711	**50**	0.002344039	**73**	0.000896593
5	0.000000000	**28**	0.000101479	**51**	0.000162953	**74**	0.000639898
6	0.000027020	**29**	0.001342649	**52**	0.000136687	**75**	0.000000000
7	0.000000000	**30**	0.002621423	**53**	0.000141456	**76**	0.000000000
8	0.000000000	**31**	0.001283019	**54**	0.000105871	**77**	0.000212134
9	0.000000000	**32**	0.000080390	**55**	0.004287139	**78**	0.000799574
10	0.000000000	**33**	0.000052221	**56**	0.001503395	**79**	0.000000000
11	0.000000000	**34**	0.000887049	**57**	0.012738854	**80**	0.000000000
12	0.000104488	**35**	0.000055033	**58**	0.007714621	**81**	0.000000000
13	0.000000000	**36**	0.001367129	**59**	0.003890510	**82**	0.000000000
14	0.000000000	**37**	0.000029534	**60**	0.002455796	**83**	0.000000000
15	0.000000000	**38**	0.000124251	**61**	0.000856348	**84**	0.000000000
16	0.000000000	**39**	0.000063625	**62**	0.000239139	**85**	0.000000000
17	0.000028446	**40**	0.000031332	**63**	0.000000000	**86**	0.000446828
18	0.000028697	**41**	0.000000000	**64**	0.000284846	**87-107**	0.000000000
19	0.000109788	**42**	0.000450872	**65**	0.000814185		
20	0.000052904	**43**	0.001230054	**66**	0.014140647		
21	0.000026511	**44**	0.004987985	**67**	0.006297529		
22	0.000000000	**45**	0.000146654	**68**	0.000000000		

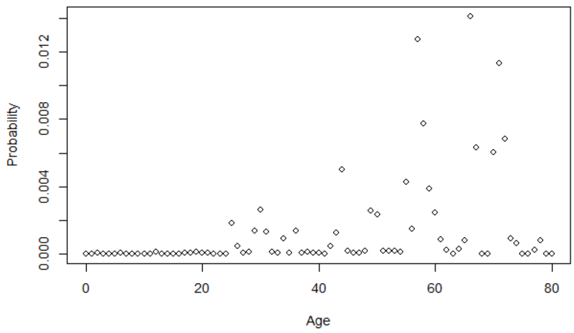

Figure 4 Graph of Empirical Morbidity Table at age.

Table 2 Empirical Morbidity Table at Age Group.

Age Group	Probability
0-10	0.00000596246
11-20	0.00003241535
21-30	0.00065884090
31-40	0.00041985314
41-50	0.00115433410
51-60	0.00300741583
61-70	0.00273310623
71-80	0.00247665523
81-90	0.00005388512
91-100	0
101-110	0

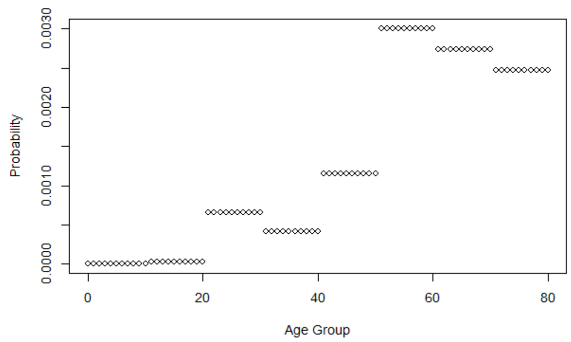

Figure 5 Graph of empirical morbidity table at age group.

The graph of the empirical morbidity table in **Figure 5** shows that the morbidity rate for the age group [0,10] continues to rise until declining in the age group [31,40]. Then, the morbidity rate rises again and reaches its peak in the age group [51,60], after which it continues to decline. Additionally, the graph indicates that the increase in morbidity rate from the age group [41,50] to the age group [51,60] is the greatest.

3.3 Interpolation

In the previous section, it was explained that interpolation is one of the methods used to estimate values between existing data points. It can be observed from the data that in the age group exceeding 80 years, the probability of suffering from genitourinary diseases is very small, approaching zero.

In this study, interpolation will be carried out for ages between 0 and 80 years. Furthermore, for ages exceeding 80 years, extrapolation will be performed. Interpolation will be using the cubic spline method on age data and age group data with and without the use of knots. Knots are points where two splines meet. Interior knots are knots that are not located at the ends of the graph. In other words, knots serve as boundaries between two splines. Please refer to **Figure 5**, which shows that the probability of suffering disease increases from age 0 to 30 years. The probability then decreases from 30 to 40 years and then increases again after the age of 40. This indicates the intersection of two splines at the age of 40, so a knot is chosen at the age of 40. The following are the results of the interpolation from the data.

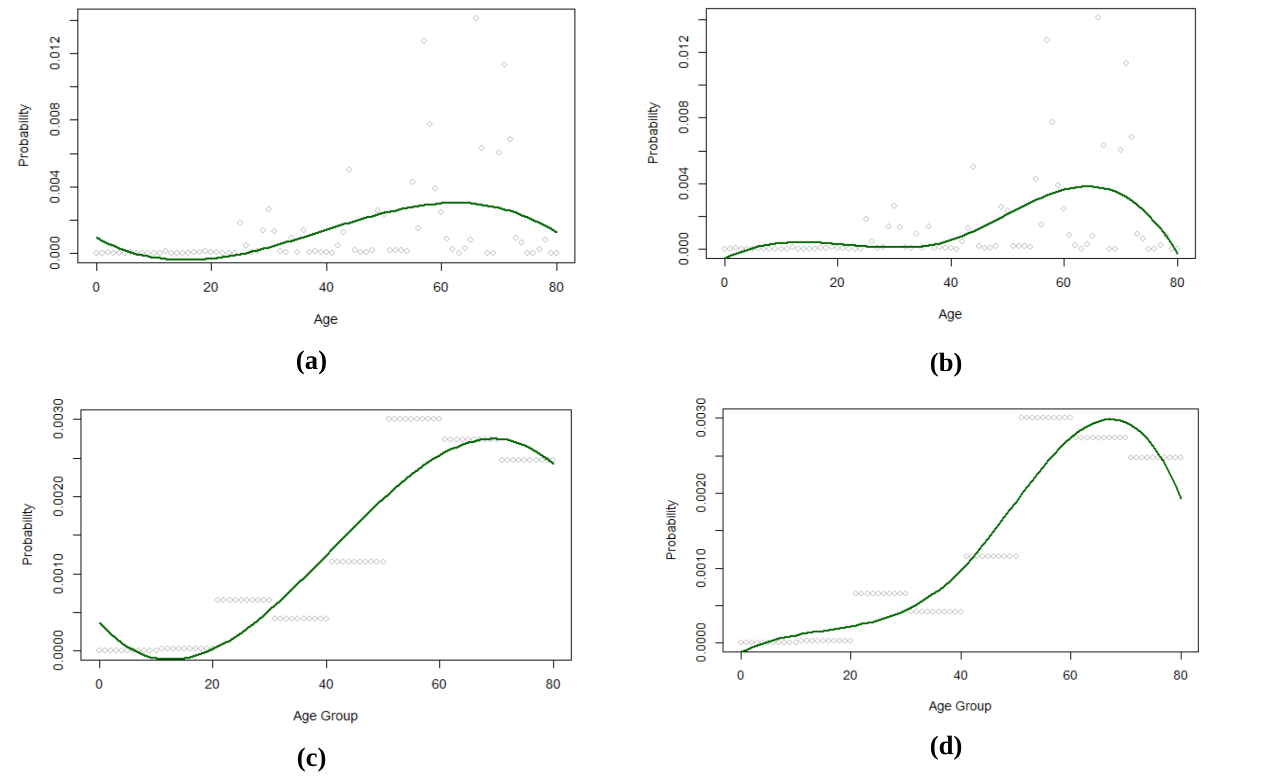

Figure 6 **Interpolation of Empirical Morbidity Table (a) at Age Without Knot, (b) at Age with Knot, (c) at Age Group Without Knot, (d) at Age Group With Knot.**

With visual interpretation, it is obvious that the interpolation results shown in **Figure 6(d)** are the most representative of the data compared to other interpolation results shown in **Figure 6(a)**, **Figure 6 (b)**, **Figure 6 (c)**, **Figure 6 (d)**. To ensure the selection of the best model, the best model is determined based on the R-square.

Table 3 **R-square value for each model.**

Interpolation	*R-square*
At age without knot	0.194
At age with knot	0.2481
At age group without knot	0.878
At age group with knot	0.9094

Based on R-square values on **Table 3**, the model from interpolation at age groups with knot has 0.9094 R-square value, which is the highest R-square value compared to others. Therefore, based on visual observation from **Figure 6(d)** and the comparison of R-squares at **Table 3**, the model from interpolation at age groups with knot is the best model to represent data.

3.4 Extrapolation

Extrapolation is carried out to extend the rate up to a certain age because the available data within that age range is limited and not sufficient to represent the morbidity rate **[22]**. As mentioned in the previous section, extrapolation is performed using the Whittaker-Henderson method. In **Figure 4** and **Figure 5**, it can be seen that for ages over 80 years, the number of exposures is minimal, which can affect the number of claims in that age group. For this reason, in this study, extrapolation is performed for the ages over 80 years. Extrapolation is extended up to the age of 85 years because in **[22]**, the age of 85 years is chosen as the upper limit for extrapolation. The reason for it is considering the coverage trend in the Critical Illness product industry. Below are the extrapolation results for ages (80, 85].

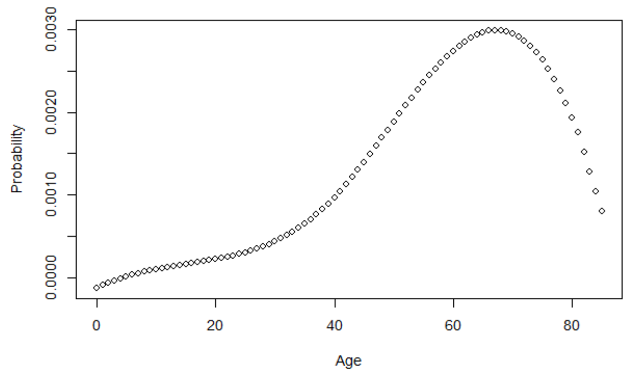

Figure 7 **Graph of extrapolation results for ages 81 to 85 years.**

3.5 Prediction of Indonesia Morbidity Table

Based on interpolation and extrapolation performed before, we obtain a prediction of morbidity table related to genitourinary system disease. Predicted morbidity table is shown by Table 4 below.

Table 4 **Prediction of Indonesia Morbidity Table for Genitourinary System Disease.**

Age	I_x	Age	I_x	Age	I_x	Age	I_x
0	0.00000	**22**	0.00025	**44**	0.00131	**66**	0.00298
1	0.00000	**23**	0.00027	**45**	0.00140	**67**	0.00299
2	0.00000	**24**	0.00029	**46**	0.00149	**68**	0.00299
3	0.00000	**25**	0.00031	**47**	0.00159	**69**	0.00297
4	0.00000	**26**	0.00033	**48**	0.00169	**70**	0.00295
5	0.00002	**27**	0.00035	**49**	0.00179	**71**	0.00291
6	0.00004	**28**	0.00038	**50**	0.00189	**72**	0.00286
7	0.00006	**29**	0.00041	**51**	0.00198	**73**	0.00280
8	0.00008	**30**	0.00044	**52**	0.00208	**74**	0.00272
9	0.00009	**31**	0.00048	**53**	0.00217	**75**	0.00263
10	0.00011	**32**	0.00052	**54**	0.00227	**76**	0.00252
11	0.00012	**33**	0.00056	**55**	0.00236	**77**	0.00240
12	0.00013	**34**	0.00060	**56**	0.00244	**78**	0.00226
13	0.00014	**35**	0.00065	**57**	0.00252	**79**	0.00210
14	0.00016	**36**	0.00071	**58**	0.00260	**80**	0.00193
15	0.00017	**37**	0.00077	**59**	0.00267	**81**	0.00176
16	0.00018	**38**	0.00083	**60**	0.00274	**82**	0.00152
17	0.00019	**39**	0.00090	**61**	0.00280	**83**	0.00128
18	0.00020	**40**	0.00097	**62**	0.00285	**84**	0.00104
19	0.00021	**41**	0.00105	**63**	0.00290	**85+**	0.00080
20	0.00022	**42**	0.00113	**64**	0.00293		
21	0.00024	**43**	0.00122	**65**	0.00296		

4. CONCLUSIONS

Based on the modeling process of the morbidity table that has been conducted, interpolation based on age groups with knots is the best interpolation result that represents the data. This is because this interpolation method has the highest R-square value compared to other interpolation methods considered in the morbidity table modeling process. Extrapolation is performed in the age range of 80 years to 85 years in this study. Extrapolation is carried out for ages above 80 years because, at this age, the number of exposures is relatively low, which can affect the number of claims in that age group. On the other hand, based on the Morbidity Table of Critical Illness of Indonesia, the age limit of 85 years is chosen as the end limit for extrapolation due to the coverage trend in Critical Illness products in the industry.

In the predicted morbidity table shown in **Table 4** above, it is noticeable that diseases related to the genitourinary system have the potential to affect almost all age groups, except for individuals in the toddler age group. Additionally, from the morbidity table predictions, it can be observed that the likelihood of someone suffering from genitourinary system diseases starts to increase significantly around the age of 25 and peaks around the age of 65, before gradually decreasing towards the later years.

This phenomenon makes sense, as according to the labor force diagram attached in **[16]**, individuals aged 15 and above are categorized as part of the working-age population, and on average, countries set the retirement age for workers at around 60 years. Those in the working-age population tend to have busier activities compared to those who are not in the working-age group. On the other hand, individuals who have surpassed the working age, for the most part, are retired and do not engage in intensive activities. Additionally, the population aged 65 and above starts to decline due to an increase in mortality rates for the elderly population.

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