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Determination of Community-Based Health Microinsurance Premiums Based on Health Costs

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Abstract

Low-income households are faced with the financial risk of paying large medical bills when a member of the household falls ill. This health-related risk can affect household welfare because meeting medical expenses has the potential to reduce income capacity. Community-based health insurance is seen as one mechanism for vulnerable low- and middle-income households to overcome barriers and to improve access to health care and financial protection. This research was conducted to determine the calculation of community-based health microinsurance premiums based on health costs and determine the average willingness to pay insurance premiums. The determination of the premium is calculated based on the pure premium and other costs. Data obtained based on surveys and data provided by health facilities. Based on the results of the research, the pure individual premium is IDR 92,297.12 per year. The total individual premium calculated based on pure premium and other costs is IDR 275,256.80 per year. If the premium is paid monthly, a premium of IDR 22,938.07 per month will be obtained. Then the average value is obtained WTP or willingness to pay IDR 38,368.42 per month. The average value of the willingness to pay is greater than the total monthly health micro insurance premium that has been determined.

Keywords: Microinsurance; Health; Premium; Willingness to Pay

1. Introduction

Basically, every human being faces risks in their lives, one of which is the possibility of falling ill or unexpected health threats. For low-income households, this can pose a financial risk in paying large medical bills when a member of their household falls ill. In Woldemichael et al. (2016) state that common ways to handle large medical bills are by borrowing, saving, selling assets, reducing consumption levels, or collectively neglecting medical care. However, not all of these methods provide a good impact, they can also have a detrimental effect on household welfare.

Community-based health insurance is seen as one mechanism for low- and middle-income households vulnerable to overcoming various barriers and improving access to healthcare and financial protection (Chemouni, 2018). The term community-based health insurance is used to refer to resource pooling mechanisms at the community level in the provision of healthcare services, including microinsurance mechanisms. Generally, microinsurance provides limited benefits to members with low premiums that are affordable for low-income households. In insurance, estimating willingness to pay for health insurance is crucial in determining the financial limits in benefit design or planning (Binnendijk et al., 2013).

This study aims to determine the premium of community-based health microinsurance based on healthcare costs. The calculation of the total individual premium is based on pure premiums and other costs. The probability of falling ill is determined using data on the number of illness occurrences. Additionally, this research determines the average willingness to pay for health microinsurance premiums.

2. Literature Review

2.1. Microinsurance

Microinsurance plays a role as a financial instrument that assists low-income households in reducing risks and preparing for unforeseen circumstances (Adhana & Saxena, 2017). The term "micro" in its product characteristics indicates low premiums, low coverage levels, affordability, and easy accessibility.

2.1.1 Health Microinsurance

Health microinsurance is a community-based, low-cost health insurance that provides financial protection for households and improves access to healthcare (Dror, 2018).

2.2. Probability Distribution Function

2.2.1. Discrete Random Variables

A discrete random variable is a countable random variable. The probability mass function of a discrete random variables X is defined as follows:

$$p(x) = P(X = x). \tag{1}$$

The cumulative distribution function of a random variable X is defined as

$$F(x) = P(X \leq x) = \sum_{t \leq x} p(t) \tag{2}$$

and the following equation holds

$$P(X \geq x) = 1 - P(X < x) \tag{3}$$

for all real numbers X.

2.2.2. Poisson distribution

The Poisson distribution is a discrete probability distribution that represents the number of discrete events that occur during a specific time interval (Cox & Miller, 1977).

1) When a random variable follows a Poisson distribution with a parameter $\lambda > 0$, its probability function is:

$$p(x) = \frac{e^{-\lambda}\lambda^x}{x!} \tag{4}$$

2) The cumulative distribution function is:

$$F(x) = P(X \leq x) = \sum_{i=0}^{x} \frac{e^{-\lambda}\lambda^i}{i!} \tag{5}$$

3) The moment generating function of is as follows:

$$M(t) = e^{\lambda(e^t - 1)} \tag{6}$$

4) The expected value is the first derivative of the moment generating function evaluated at $t = 0$.

$$E(X) = \lambda \tag{7}$$

5) The variance is given by:

$$Var(X) = \lambda \tag{8}$$

2.3. Kolmogorov Smirnov Goodness of Fit Test

The Kolmogorov Smirnov test is used to test the goodness of fit of an observed sample distribution with a specific theoretical distribution (Kusumadewi et al., 2022). The Kolmogorov Smirnov test measures the maximum absolute difference between $F_0(x)$, which is the cumulative distribution function of the population, and $F_k(x)$, which is the empirical distribution function of the sample. It can be expressed as follows:

$$D = \max\{|F_k(x) - F_0(x)|\} \tag{9}$$

With the following hypotheses:

H_0 : The data follows the theoretical distribution.

H_1 : The data does not follow the theoretical distribution.

The decision criterion for the Kologorov Smirnov test is: if $D < D_{critical}$, then H_0 is accepted, meaning that the observed sample distribution is the same as the theoretical distribution (Razali & Wah, 2011).

2.4. Maximum Likelihood Estimation

Maximum Likelihood Estimation (MLE) is used to estimate a specific point by maximizing the likelihood function. For example, let $X_1, X_2, \dots, X_n$ be a random sample following a Poisson distribution with parameter λ. MLE is used to estimate the parameter. Based on the MLE method, the parameter estimation for the Poisson distribution is given by:

$$\hat{\lambda} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{10}$$

2.5. Premium

2.5.1. Pure Premium

There are several indicators used to calculate the pure premium, namely the probability of healthcare service utilization, the average number of healthcare service utilization, and the average unit cost. The following is an equation for pure premium (STEP, 2005):

$$P = p \times AQ \times AUC \tag{11}$$

1) The probability of utilizing healthcare services is denoted by p:

$$p = \frac{Ps}{Pr} = \frac{Pi}{Pr} \times \frac{Pf}{Pi} \times \frac{Ps}{Pf} \tag{12}$$

where Pi/Pr represents the probability of falling ill, Pf/Pi is the expected proportion of using health facilities, and Ps/Pf is the proportion of facility users in a specific service.

2) The average number of healthcare service utilization is the number of times a specific healthcare service is used by service users.

$$AQ = \frac{\sum_{k=1}^{n} k \cdot n_k}{\sum_{k=1}^{n} n_k} \tag{13}$$

where AQ is the average number of healthcare service utilization, k detones the frequency of service utilization per year, and n_k is the number of patients using the healthcare service k times.

3) The average unit cost of a healthcare service refers to the average cost incurred by an individual for a particular healthcare service (STEP, 2005). The average unit cost can be expressed as the following equation:

$$AUC = AC \tag{14}$$

where AC denotes the average cost (per service).

2.5.2. Safety Loading

Safety loading provides a cushion for the losses that will be borne by the insurance scheme if the actual cost of the risk exceeds the initially calculated pure premium. According to STEP (2005), this risk can be determined by the coefficient (N, p) which is calculated using one of the properties of the standard normal distribution, namely the calculation of the $\mathbf{I}\, P_{0.998}$ confidence interval that includes the expected proportion of consumers with a 99/100 probability. Where N is the estimated number of population to be covered by insurance and p is the probability of healthcare service utilization. The safety loading can be determined by the following equation:

$$\tau = koefisien\,(N, p) \times P \tag{15}$$

2.5.3. Unit Operating Costs

The operational costs of the health microinsurance scheme is charged to each individual. The initial estimate of the operational cost figure can be determined as +/-10 percent of the total pure premium and safety loading.

$$OUC = 10\% \times (P + \tau) \tag{16}$$

2.5.4. Surplus

The determination of surplus units from health microinsurance is calculated for each healthcare service. The desired percentage for determining surplus units in premium calculation is 5%.

$$S = B\% \times (P + \tau + OUC) \tag{17}$$

2.5.5. Total Premium

The final result of the total annual individual premium is obtained by using the equation:

$$P_T = P + \tau + OUC + S \tag{18}$$

2.6. Willingness to Pay

Willingness to pay (WTP) is a methodological tool used to evaluate the payment capacity of a specific social group and also estimate the monetary value for a particular program. In other words, WTP is defined as the maximum amount that a person is willing to pay for goods or services (Azhar et al., 2018).

In estimating the average expected value of WTP from respondents who are willing to pay, it is calculated using the following equation (Afroz et al., 2017):

$$E(WTP) = \sum_{i=1}^{n} W_i(Pf_i) \tag{19}$$

where $E(WTP)$ is the estimated mean value of WTP (Rp), W_i is the WTP value (Rp), Pf_i is the relative frequency (%), i refers to the i-th the respondent willing to pay a premium, and n is the number of samples.

3. Materials and Methods

3.1. Materials

The objects of this study are the data on the utilization of healthcare facilities, the unit costs of outpatient healthcare services obtained from primary healthcare service data, and data on hospital inpatient services referred to during the period from January 2022 to December 2022. Additionally, data on illness occurrences, utilization of healthcare services, and willingness to pay were obtained through questionnaires.

3.2. Methods

The initial step taken in this study was to collect data on illness occurrences, healthcare utilization in terms of services, and willingness to pay which were obtained through questionnaires. Additionally, data on healthcare facility usage and unit costs of healthcare services were obtained from the provided data by healthcare facilities.

Based on the data obtained from the conducted survey, the goodness of fit test using the Kolmogorov-Smirnov test was performed for the illness occurrence data. Then, the distribution parameters of the data were estimated using maximum likelihood estimation. The determination of the probability of falling ill was done using probability distribution. EasyFit software and Microsoft Excel were used to expedite the calculation process. Next, the proportions of patients expected to utilize healthcare facilities and the proportions of healthcare service users were determined. Based on these indicators, the probability of healthcare service utilization was calculated. Subsequently, the calculation of health microinsurance premiums was determined based on pure premiums and other costs, such as safety loading, unit operational costs, and surplus. The results yielded the total individual premiums per year. Finally, the average willingness to pay for insurance premiums was calculated based on the maximum premium amount that individuals were willing to pay.

4. Results and Discussion

4.1. Number of Occurrences Data

In this study, a survey was conducted on 99 general patients at the primary healthcare center. The number of illness occurrences data is assumed to follow a Poisson distribution. The histogram graph of the number of occurrences data, generated using EasyFit software, is shown below:

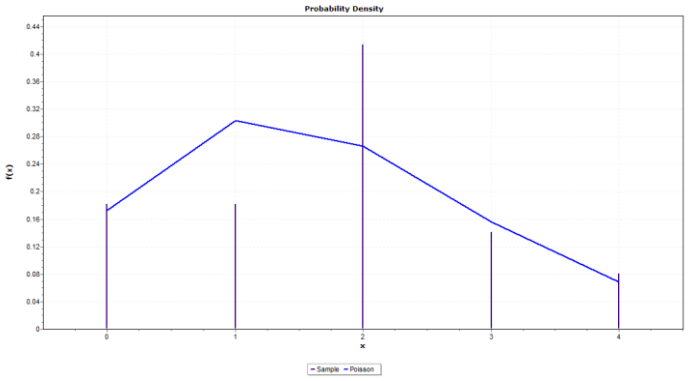

Figure 1: Histogram of the number of illness occurrences

The suitability test for the distribution of the number of occurrences was conducted using the Kolmogorov-Smirnov test with the assistance of EasyFit software, with the following hypotheses:

H_0 : The data follows a Poisson distribution.

H_1 : The data does not follow a Poisson distribution.

The results of the Kolmogorov-Smirnov test at a 95% significance level for the number of occurrences data are presented in Table 1.

Table 1: Kolmogorov-Smirnov test for the number of occurrences data

Number of occurrences	Test Statistic (D)	0.11194
	$D_{critical}$	0.13669
	Result	$D < D_{critical}$
	Conclusion	H_0 is accepted

Based on the results of the Kolmogorov-Smirnov goodness-of-fit test in Tabel 1, H_0 is accepted. This means that the number of occurrences data follows a Poisson distribution.

Subsequently, parameter estimation is determined using the Maximum Likelihood Estimation (MLE) method based on equation (10).

$$\hat{\lambda} = \frac{\Sigma x_i}{99}$$

By using Microsoft Excel software, the parameter estimation λ for the number of occurrences data is obtained as $\lambda = 1.75758$ in the equation.

4.2. Probability of Healthcare Service Utilization

Based on the estimated parameter λ, the probability of falling ill is calculated using equation (3) as follows:

$$P(X \geq 1) = 1 - P(X < 1)$$

$$= 1 - P(x = 0) = 1 - \frac{e^{-\lambda}\lambda^0}{0!} = 0.83$$

Based on the survey data and healthcare service utilization data, the following table presents the proportions and determination of the probabilities of healthcare service utilization for each service covered under the insurance scheme.

Table 2: Probability of healthcare service utilization

Healthcare Service	Pi/Pr	Pf/Pi	Ps/Pf	Probability (p)
General clinic	0.83	0.96809	0.69549	0.55
Dental clinic	0.83	0.96809	0.07767	0.05
Maternal and child health clinic	0.83	0.96809	0.10062	0.1
Laboratory	0.83	0.96809	0.12273	0.1
Emergency unit	0.83	0.96809	0.00349	0.01
Inpatient care	0.83	0.03191	1.00000	0.03

4.3. Calculation of Pure Premium

Based on three indicators of pure premiums, namely the probability of healthcare utilization in Table 2, the average amount covered using equation (13), and the average unit cost of healthcare services using equation (14), the determination of pure premiums is calculated for each healthcare service using equation (11).

Table 3: Pure premium

Healthcare Service	p	AQ	AUC	Pure Premium (P)
General clinic	0.55	1.55500	8,108.72	6,934.98
Dental clinic	0.05	1.37473	18,521.81	1,273.12
Maternal and child health clinic	0.1	1.36033	13,417.98	1,825.29
Laboratory	0.1	1.12602	46,391.10	5,223.73
Emergency unit	0.01	1.00000	16,333.33	163.33
Inpatient care	0.03	3.12057	821,181.82	76,876.66
	Total			92,297.12

Based on Table 3, the total pure premium for each individual is obtained to be IDR 92,297.12 per year.

4.4. Calculation of Total Premium

The calculation results of the total individual premiums per year are presented in Table 4.

Table 4: Total premium

Healthcare Service	Pure Premium (P)	Safety Loading (τ)	Unit Operational Cost (OUC)	Surplus (S)	Total Premium (P_T)
General clinic	6,934.98	1,941.80	887.68	488.22	10,252.68
Dental clinic	1,273.12	1,718.72	229.18	164.55	3,455.58
Maternal and child health clinic	1,825.29	1,697.52	352.28	193.75	4,068.84
Laboratory	5,223.73	4,858.07	1,008.18	554.50	11,644.48
Emergency unit	163.33	501.43	66.48	36.56	767.81
Inpatient care	76,876.66	135,302.92	21,217.96	11,669.88	245,067.42
Total					275,256.80

Based on Table 4, the total individual premium per year amounts to IDR 275,256.80. If the premium is paid on a monthly basis, the premium amount would be IDR 22,938.07.

4.5. Average value of Willingness to Pay

Based on the survey results, out of 99 respondents, a total of 95 individuals are willing to pay for health microinsurance premiums. The willingness to pay is calculated based on the maximum premium amount they are willing to pay on a monthly basis. The lowest value individuals are willing to pay is IDR 10,000.00 per month, while the highest value is IDR 100,000.00 per month. The average value of WTP is calculated using equation (19) and presented in Table 5.

Table 5: Average WTP value

WTP value	Frequency	Relative Frequency (%)	Average WTP Value (IDR/month)
100,000.00	9	9.47	9473.68
80,000.00	6	6.32	5052.63
60,000.00	10	10.53	6315.79
50,000.00	3	3.16	1578.95
40,000.00	9	9.47	3789.47
30,000.00	2	2.11	631.58
25,000.00	2	2.11	526.32
20,000.00	50	52.63	10526.32
15,000.00	1	1.05	157.89
10,000.00	3	3.16	315.79
Average WTP value			38,368.42

Based on Table 5, the average WTP value for health microinsurance premium is IDR 38,368.42 per month. This means that the average WTP value for willingness to pay towards the premium is 67.27% higher than the total health microinsurance premium per month, which is IDR 22,938.07.

5. Conclussion

Based on the research results, the pure premium for micro health insurance per individual is IDR 92,297.12 per year. The total individual premium for micro health insurance, including the pure premium and other costs, is IDR 275,256.80 per year. If the premium is paid on a monthly basis, the premium amount obtained is IDR 22,938.07. Furthermore, the average Willingness to Pay (WTP) value for micro health insurance premium is IDR 38,368.42 per month, indicating that on average, it is 67.27% higher than the total predetermined monthly premium for micro health insurance.

References

Adhana, D., & Saxena, M. (2017). Micro insurance in India: a powerful tool to empower poor. *Asia Pacific Journal of Research in Business Management*, *8*(7).

Afroz, R., Akhtar, R., & Farhana, P. (2017). Willingness to pay for crop insurance to adapt flood risk by Malaysian farmers: An empirical investigation of Kedah. *International Journal of Economics and Financial Issues*, *7*(4), 1-9.

Azhar, A., Rahman, M. M., & Arif, M. T. (2018). Willingness to pay for health insurance in Sarawak, Malaysia: a contingent valuation method. *Bangladesh Journal of Medical Science*, *17*(2), 230-237.

Binnendijk, E., Dror, D. M., Gerelle, E., & Koren, R. (2013). Estimating Willingness-to-Pay for health insurance among rural poor in India by reference to Engel's law. *Social science & medicine*, *76*, 67-73.

Chemouni, B. (2018). The political path to universal health coverage: power, ideas and community-based health insurance in Rwanda. *World Development*, *106*, 87-98.

Cox, D. R., & Miller, H. D. (1977). *The theory of stochastic processes* (Vol. 134). CRC press.

Dror, D. M. (2018). Estimating Willingness-to-Pay for Health Insurance Among Rural Poor in India by Reference to Engel's Law. *World Scientific Book Chapters*, 139-149.

Kusumadewi, R., Riaman, R., & Sukono, S. (2022). Determining the Price of Fisherman Micro Insurance Premiums Using the Aggregate Risk Model Approach in Cirebon Regency. *International Journal of Quantitative Research and Modeling*, *3*(3), 118-123.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. *Journal of statistical modeling and analytics*, *2*(1), 21-33.

STEP, I. (2005). Health Microinsurance Schemes: Feasibility Study Guide.

Woldemichael, A., Gurara, D. Z., & Shimeles, A. (2016). Community-based health insurance and out-of-pocket healthcare spending in africa: evidence from Rwanda. *Available at SSRN 2776927*.