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SOCIAL VULNERABILITY INDEX TO TUBERCULOSIS OF PROVINCES IN INDONESIA

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ABSTRACT
Tuberculosis is still one of the world's health problems. Tuberculosis cases generally occur in developing countries, including Indonesia. Indonesia has become one of the countries that have not reached the SDGs targets related to tuberculosis and become a country with the second largest number of new cases in the world after India. The high incidence of tuberculosis is related to the level of vulnerability. Therefore, it is essential to conduct research that can measure the level of vulnerability. This study intends to categorize provinces in Indonesia according to the level of social vulnerability of tuberculosis (TB). The data used in this research is sourced from the National Economic and Social Survey (Susenas) conducted by the Indonesian Bureau of Statistics (BPS). The method used in this research is factor analysis. From factor analysis can be identified four social vulnerability factors (housing and exposure of smoke factor, economic factor, social demography factor, and welfare factor) able to explain variance equal to 73,40 percent. The four factors formed are then used to form a Social Vulnerability Index or Indeks Kerawanan Sosial (IKS). Based on the results of the grouping of provinces according to the IKS, there are 6 provinces with very low social vulnerability, 4 provinces with low social vulnerability, 14 provinces with middle social vulnerability, and 8 provinces with high social vulnerability. Two provinces in Indonesia are categorized into very high social vulnerability group which are Papua and East Nusa Tenggara.

Keywords: Grouping, Social vulnerability, Tuberculosis, Factor analysis, Social vulnerability index

1. INTRODUCTION

Tuberculosis (TB) is still one of the world's health problems until now although control efforts have been implemented since 1995. According to the World Health Organization (WHO), tuberculosis infection is generally asymptomatic (patients are unaware of any symptoms) and latent. Only one in ten cases of latent infection develop into active disease (World Health Organization 2017). If tuberculosis is not treated, then more than 50 percent of infected people can die. Based on WHO report, there are 1.7 million people died from TB in 2016. Although the TB mortality rate fell by 37% between 2000 and 2016, TB is still one of the top 10 causes of death worldwide (World Health Organization 2017).

Tuberculosis is not spread evenly throughout the world. Of the populations in various countries in Asia and Africa who tested tuberculin, 80% of them showed positive results, while in the United States, only 5-10% were positive (Kumar, Abbas, and Aster 2012). In 2016, there were an estimated 10.4 million new (incident) TB cases worldwide, of which 64% are accounted in India, Indonesia, China, Philippines, Pakistan, Nigeria, and South Africa. Indonesia is the country with the second largest number of new TB cases in the world after India worldwide (World Health Organization 2017).

Tuberculosis becomes one of the points in the Sustainable Development Goals (SDGs), which is goal 3 target 3.3. WHO set the specific targets to reduce 90% of TB deaths and 80% TB incidence by 2030, compared with 2015 worldwide (World Health Organization 2017). In Indonesia, tuberculosis is one of the national priorities for disease control programs contained in the National Medium-Term Development Plan (RPJMN) (Kementerian Kesehatan Republik Indonesia 2017). In

2016, the TB incidence rate in Indonesia is 391 cases per 100.000 populations and TB mortality rate is 42 per 100.000 populations (people with human immunodeficiency virus (HIV) excluded) worldwide (World Health Organization 2017). Including people with HIV, the mortality rate is 5,1 per 100.000 populations worldwide (World Health Organization 2017). Based on data from Indonesia Ministry of Health (Kemenkes RI), Indonesia has not achieved the prevalence target contained in RJPMN. Tuberculosis prevalence target in 2016 was 271 per 100,000 population, while the achievement was 257 per 100,000 populations (Kementerian Kesehatan Republik Indonesia 2017).

The high incidence of tuberculosis is related to the level of vulnerability. Therefore, it is important to conduct vulnerability measurement studies. The vulnerability indicator is a useful tool to identify and to monitor the vulnerabilities over time in a given scope, to develop a fundamental understanding of vulnerability processes, to develop strategies to reduce vulnerability, and also to prioritize and to determine the effectiveness of vulnerability reduction strategies (Rygel, O'Sullivan, and Yarnal 2006).

The measurement of vulnerability can be viewed from many aspects, one of which is social. The vulnerability of social aspects refers to human well-being including mental and physical health to individuals and collective levels (including health, education and others), social systems and individual characteristics such as gender and marginalization of social groups (Birkmann et al. 2013). Therefore, in this study the level of vulnerability will be seen from the social aspects, namely the measurement of social vulnerability to tuberculosis disease in each province in Indonesia in 2016.

Research on the social vulnerability to tuberculosis has many benefits. One of them is to prevent the losses caused by tuberculosis and to reduce the risk of the spread of tuberculosis. Given the grouping of areas based on vulnerability to tuberculosis, it is hoped that policymakers can develop more precise strategies to reduce the vulnerability by prioritizing areas with high levels of vulnerability. Thus, aligned with SDGs goal 3, the effectiveness of the vulnerability reduction strategy can be achieved.

The purpose of this research is to know the factors influencing social vulnerability to tuberculosis in Indonesia, to get the measurement of social vulnerability index to tuberculosis in Indonesia, and to grouped provinces in Indonesia according to social vulnerability index to tuberculosis. This paper is structured as follows: Section 2 explores the theory related to tuberculosis, vulnerability, and social vulnerability index. Section 3 presents the methodology used to conduct this research. Section 4 explains the findings obtained from social vulnerability to tuberculosis measurement and classification. Finally, the last section is the conclusion of this study.

2. METHOD

The data used in this study are secondary data obtained from the Indonesian Bureau of Statistics (BPS) in the form of data publication, derived from the 2016 National Socio-Economic Survey (Susenas). The analysis unit in this study is all provinces in Indonesia (34 provinces). The variables used in this study are adopted from the main causes of the increased of tuberculosis written on the national tuberculosis guidelines, Indonesia Ministry of Health (Kementerian Kesehatan Republik Indonesia 2015) and also from the common factors that cause a person's vulnerability to a disease based on Dunn and Richardson (Dunn and Richardson 2005). Variables that will be used in this research are:

1. Percentage of population aged 15 years and over.
2. Percentage of male population.
3. Percentage of population with low education.

4. Low-educated residents of the population aged 15 years and over who are educated or have a final diploma of junior high school and elementary school, did not complete primary school, and who have not / never attended school.
5. Open Unemployment Rate.
6. Percentage of poor population.
7. Percentage of households with not feasible sanitation.
8. Unsuitable sanitation criteria are non-joint or joint toileting facilities, type of toilets instead of goosenecks, and final stool disposal sites instead of tanks / SPALs.
9. Percentage of households with occupancy area per capita ≤ 7.2 m^2.
10. Occupancy area per capita is the floor area divided by the number of household members (ART). It is assumed that every household consists of 5 ART and according to UU No. 1 of 2011 on housing, the minimum occupancy area is 36 m^2, then the minimum area per capita is 7.2 m^2.
11. Percentage of households with not feasible roof (roof of palm fibers / other).
12. Percentage of households with bamboo walls / other.
13. Percentage of households with not feasible floor (ground floor).
14. Percentage of households with fuel / primary energy for cooking using firewood.
15. Average monthly expenditure per capita.
16. Number of health facilities.
17. Number of existing health facilities in a region, including general hospitals, special hospitals, and community health centers (puskesmas).
18. Percentage of smoking in the population aged 15 years and over.

The fourteen variables used in this study were first analyzed using factor analysis to derive factors that affect social vulnerability to tuberculosis in Indonesia. After obtaining factors that affect the level of social vulnerability to tuberculosis, the second step is to calculate the social vulnerability index of tuberculosis disease in Indonesia. Social vulnerability is usually measured using SOVI (Social Vulnerability Index). Measurement of vulnerability by combining some indicators to obtain characteristics or parameters depicting a SOVI system is a measurement proposed by (Cutter, Boruff, and Shirley 2003). The measurement has been adopted in several studies. (Siagian et al. 2014) adopted it to see the differences in the levels of social vulnerability to environmental disasters between provinces in Indonesia. (Yang et al. 2014) used SOVI to assess provincial social vulnerability to natural disaster in China. Related to health, (Xiaoling and Ruopeng 2015) also adopted SOVI to measure the social vulnerability of U.S. counties and examined the associations with obesity. The social vulnerability index is made of synthesis of socioeconomic variables through factor analysis process. The variables used are variables that influence disaster or social occurrence that happened. In this study, the index used to see the difference of social vulnerability to tuberculosis among provinces in Indonesia which called IKS (Indeks Kerawanan Sosial). The calculation of IKS follows the SOVI calculation steps.

The calculation step of IKS is to determine the formula of IKS calculation of the factor that formed. The calculation formula of IKS can be done by using two ways: equal weighted and unequal weighted. The factors obtained were applied to a model using the formula to obtain the IKS equation. The obtained IKS equation is used to calculate the IKS score of each province. After obtaining the score of IKS, each province then categorized the condition of vulnerability using the standard deviation method into 5 categories. According to (Azwar 2008), if the data is normally distributed then the division into 5 categories can follow the following rules:

$x \leq -1{,}5\sigma$	Very Low Category
$-1{,}5\sigma < x \leq -0{,}5\sigma$	Low Category
$-0{,}5\sigma < x \leq +0{,}5\sigma$	Medium Category

$+0{,}5\sigma < x \leq +1{,}5\sigma$ High Category
$x > +1{,}5\sigma$ Very High Category

After grouping the provinces into appropriate categories, researchers created maps as visualizations depicting the level of vulnerability according to the IKS results per province.

3. RESULTS AND DISCUSSION

The first step taken in factor analysis is to form a correlation matrix. From the correlation matrix formed can be seen whether the data meet the correlation assumption. In checking the assumption is used Bartlett's of Sphericity test and KMO value. From the processed data, obtained the test results of these two assumptions are shown in Table 1. The value of KMO in this study is 0.589 (more than 0.5) means that the data meet for the analysed factor or as stated by (Sharma 1996), the data are enough for factor analysis because it is between $0.5 \leq KMO < 0.6$. Bartlett's of Sphericity test results indicate a high significance (p-value = 0.000 or < 0.05) so it can be concluded the initial hypothesis (H0) which states that the correlation matrix is the identity matrix is rejected or in other words, the correlation matrix is not an identity matrix.

Table 1. KMO and Bartlett's of Sphericity Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0,589**
Bartlett's Test of Sphericity	Approx. Chi-Square	286,962
	Df	91
	Sig.	0,000

The next step is to see the Measure of Sampling Adequacy (MSA) value of the fourteen variables. From the MSA value in Table 2 can be seen that from the fourteen variables analysed there are four variables that have MSA values less than 0.5, which are the percentage of male population, the percentage of poor people, the number of health facilities and the percentage of smoking in the population aged 15 years and over. Nevertheless, these variables are still included in the analysis because they are considered to have a strong correlation with the components formed, one of which is seen from the values of communalities in Table 3.

Table 2. Anti-Image Matrix

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
Anti-image Covariance	X1	.262	.037	-.065	.086	-.052	.032	.016	.078	.137	-.054	-.004	-.080	-.074	.101
	X2	.037	.381	-.013	-.061	.131	-.110	.017	.027	.134	-.074	.024	-.047	.160	-.005
	X3	-.065	-.013	.172	.120	.101	-.079	.024	-.041	-.062	-.019	.077	.090	-.031	-.116
	X4	.086	-.061	.120	.381	.068	-.046	.013	.005	-.025	-.027	.087	.028	-.155	-.087
	X5	-.052	.131	.101	.068	.393	-.067	-.063	.042	.028	-.092	.088	.110	.083	-.160
	X6	.032	-.110	-.079	-.046	-.067	.214	-.052	-.022	-.029	.020	-.051	.000	-.028	-.042
	X7	.016	.017	.024	.013	-.063	-.052	.298	-.115	-.043	.033	-.034	-.078	-.047	.020
	X8	.078	.027	-.041	.005	.042	-.022	-.115	.171	.115	-.072	-.009	-.007	.039	.079
	X9	.137	.134	-.062	-.025	.028	-.029	-.043	.115	.293	-.108	-.009	-.040	.071	.120
	X10	-.054	-.074	-.019	-.027	-.092	.020	.033	-.072	-.108	.148	-.074	-.022	-.113	.035
	X11	-.004	.024	.077	.087	.088	-.051	-.034	-.009	-.009	-.074	.139	.076	.054	-.060
	X12	-.080	-.047	.090	.028	.110	.000	-.078	-.007	-.040	-.022	.076	.129	.029	-.078
	X13	-.074	.160	-.031	-.155	.083	-.028	-.047	.039	.071	-.113	.054	.029	.369	-.026
	X14	.101	-.005	-.116	-.087	-.160	-.042	.020	.079	.120	.035	-.060	-.078	-.026	.395
Anti-image Correlation	X1	.573[a]	.116	-.308	.271	-.162	.135	.058	.371	.495	-.272	-.023	-.435	-.238	.313
	X2	.116	.477[a]	-.050	-.159	.339	-.386	.052	.105	.400	-.313	.104	-.211	.426	-.014
	X3	-.308	-.050	.515[a]	.468	.388	-.412	.107	-.239	-.278	-.120	.496	.606	-.125	-.445
	X4	.271	-.159	.468	.517[a]	.177	-.163	.038	.018	-.075	-.113	.378	.125	-.412	-.225
	X5	-.162	.339	.388	.177	.404[a]	-.230	-.185	.161	.083	-.382	.377	.488	.217	-.405
	X6	.135	-.386	-.412	-.163	-.230	.799[a]	-.205	-.116	-.117	.113	-.295	.002	-.099	-.144
	X7	.058	.052	.107	.038	-.185	-.205	.688[a]	-.512	-.145	.158	-.167	-.396	-.141	.059
	X8	.371	.105	-.239	.018	.161	-.116	-.512	.684[a]	.513	-.455	-.061	-.050	.155	.305
	X9	.495	.400	-.278	-.075	.083	-.117	-.145	.513	.542[a]	-.518	-.045	-.205	.217	.351
	X10	-.272	-.313	-.120	-.113	-.382	.113	.158	-.455	-.518	.630[a]	-.515	-.158	-.481	.144
	X11	-.023	.104	.496	.378	.377	-.295	-.167	-.061	-.045	-.515	.675[a]	.567	.238	-.256
	X12	-.435	-.211	.606	.125	.488	.002	-.396	-.050	-.205	-.158	.567	.594[a]	.131	-.346
	X13	-.238	.426	-.125	-.412	.217	-.099	-.141	.155	.217	-.481	.238	.131	.360[a]	-.069
	X14	.313	-.014	-.445	-.225	-.405	-.144	.059	.305	.351	.144	-.256	-.346	-.069	.394[a]

a. Measures of Sampling Adequacy(MSA)

Table 3. Value of Communalities

	Research Variable (1)	Communalities (2)
X_1	Percentage of population aged 15 years and over (%)	0,622
X_2	Percentage of male population (%)	0,683
X_3	Percentage of population with low education (%)	0,668
X_4	Open Unemployment Rate	0,772
X_5	Percentage of poor population (%)	0,515
X_6	Percentage of households with not feasible sanitation (%)	0,851
X_7	Percentage of households with occupancy area per capita ≤ 7.2 m^2 (%)	0,676
X_8	Percentage of households with not feasible roof (%)	0,794
X_9	Percentage of households with bamboo walls/other (%)	0,514
X_{10}	Percentage of households with not feasible floor (%)	0,839
X_{11}	Percentage of households with fuel/primary energy for cooking using firewood (%)	0,822
X_{12}	Average monthly expenditure per capita	0,837
X_{13}	Number of health facilities	0,887
X_{14}	Percentage of smoking in the population aged 15 years and over (%)	0,793

The variable number of health facilities has the smallest MSA value of 0.360 but has a high communalities value of 0.887. In addition, the KMO value before and after the variable excluded is not much different.

The next step is to determine the number of factors by using the scree plot and eigen value (Figure 1). In this study, it was decided to form 4 factors that influence social vulnerability to tuberculosis. The total variance explained from the four factors is 73.40 percent. Housing and exposure of smoke factor have the largest contribution of 33.70 percent. Economic factor has a contribution of 18.38 percent. Meanwhile social demographic factor has a contribution of 12.25 percent and the welfare factor has a contribution of 9.07 percent.

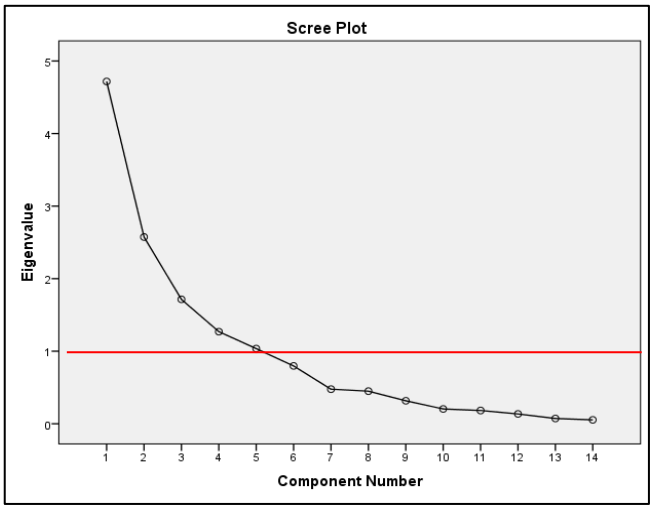

Fig. 1. Scree Plot

Table 4 shows that housing and exposure of smoke factor is the most dominant factors affecting social vulnerability to tuberculosis. There are 7 variables included in this factor, which are the percentage of households with not feasible sanitation, the percentage of households with per capita occupancy area per capita ≤ 7.2 m2, the percentage of households with not feasible roof, the percentage of households with bamboo walls/other, the percentage of houses stairs with not feasible floor, the percentage of households with fuel/primary energy for cooking using firewood, and the

percentage of smoking in the population aged 15 years and over. According to WHO, poor roofs, floors and walls are a good medium for breeding Mycobacterium tuberculosis. In the physical environment, the humidity of the house and the density of the inhabitants of the house have a significant relation with the incidence of tuberculosis. Also, poor sanitation conditions also increase vulnerability to tuberculosis. For exposure to smoke, the use of firewood is usually the cause of tuberculosis in women, while smoking is typically the cause of tuberculosis in men.

Table 4. Constructed Social Vulnerability Factors

Factors	**Research Variables**	**Eigen Value**	**Percentage of Variance Explained**
(1)	(2)	(3)	(4)
1. Housing and exposure of smoke	Households with not feasible sanitation (%) Households with occupancy area per capita ≤ 7.2 m^2 (%) Households with not feasible roof (%) Household with bamboo walls/other (%) Household with not feasible floor (%) Household with fuel / primary energy for cooking using firewood (%) Smoking in the population aged 15 years and over (%)	4,718	33,699
2. Economy	Poor population (%) Average monthly expenditure per capita	2,574	18,385
3. Social Demography	Population aged 15 years and over (%) Male population (%) Population with low education (%)	1,715	12,249
4. Welfare	Open Unemployment Rate Number of health facilities	1,269	9,067

In the second factor (economic factor) there are 2 variables included which are the percentage of the poor and the average monthly expenditure per capita. Economic growth and poverty in an area have a strong correlation, the better the income of the population of an area, the less poor people will be. Therefore, the higher the income approached by the expenditure of the population of an area, the lower the social vulnerability to tuberculosis in the area. In other words, the higher the poor population of an area, the higher the social vulnerability to tuberculosis.

On social demographic factor, there are three variables included, which are the percentage of the population aged 15 years and over, the percentage of the male population, and the percentage of the population aged 15 years and over with low education. According to WHO, tuberculosis is higher in male than female and the possibility of getting an active tuberculosis infection increases significantly according to age. Not only that, knowledge of tuberculosis that varies between households due to different levels of education obtained makes social vulnerability to tuberculosis an area is increasing.

In the welfare factor, there are two variables, which are open unemployment rate and the number of health facilities. The higher the unemployment rate of an area, the higher the social vulnerability to tuberculosis. The prevention and treatment of tuberculosis is certainly inseparable from the existence of healthcare facilities in the area. The fewer number of health care facilities in an area will increase the social vulnerability of the area to tuberculosis.

Table 5. Weight for each factor

Factors	Calculation	Weight
(1)	(2)	(3)
Housing and exposure of smoke	36,70/73,40	0,459
Economic	18,38/73,40	0,250
Social Demography	12,25/73,40	0,167
Welfare	9,07/73,40	0,124
Total		**1**

After getting the factors, the next step is to compile the social vulnerability index (IKS) from factor analysis and influencing factor direction. Based on calculations with unequal weighted weights (Table 5), an equation is found:

$$IKS = (0{,}459 * Factor1) + (0{,}250 * Factor2) + (0{,}167 * Factor3) + (0{,}124 * Factor4) \quad (1)$$

The results of the IKS score analysis of 34 provinces in Indonesia showed that the score of the IKS score ranged from 1.85 (very vulnerable) to -0.84 (slightly vulnerable). The criteria for grouping is shown in table 6. Based on IKS scores, 6 provinces in Indonesia are grouped as very low vulnerability group, 4 provinces in low vulnerability group, 14 provinces in the middle group, 8 provinces in high vulnerability group, and 2 provinces were grouped in very high social vulnerability group (table 7). Generally, Indonesia has a tendency towards middle social vulnerability, however, there are 2 provinces that are still classified as very high socially vulnerable, which are Papua and East Nusa Tenggara Provinces. The province with the highest level of social vulnerability is Papua Province. The distribution of vulnerability to tuberculosis of provinces in Indonesia is shown in figure 4.

Table 6. Criteria for Grouping

Criteria According to Standard Deviation	Calculation results	Social Vulnerability Category
(1)	(2)	(3)
$X \leq -1{,}5\sigma$	IKS ≤ -0,4610	Very Low
$-1{,}5\sigma < X \leq -0{,}5\sigma$	-0,4610 < IKS ≤ -0,1537	Low
$-0{,}5\sigma < X \leq +0{,}5\sigma$	-0,1537 < IKS ≤ +0,1537	Middle
$+0{,}5\sigma < X \leq +1{,}5\sigma$	+0,1537 < IKS ≤ +0,4610	High
$X > +1{,}5\sigma$	IKS > +0,4610	Very High

Table 7. IKS and Groupings of Provinces in Indonesia

No	Code	Province	IKS	No	Code	Province	IKS
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Very High Social Vulnerability Groups				**Middle Social Vulnerability Groups (Continued)**			
1	53	East Nusa Tenggara	1,8512	18	75	Gorontalo	-0,0051
2	94	Papua	1,7460	19	62	Central Kalimantan	-0,0263
High Social Vulnerability Groups				20	17	Bengkulu	-0,0417
3	32	West Java	0,3561	21	52	West Nusa Tenggara	-0,1016
4	76	West Sulawesi	0,2848	22	73	South Sulawesi	-0,1151
5	81	Maluku	0,2629	23	36	Banten	-0,1208
6	33	Central Java	0,2521	24	63	South Kalimantan	-0,1264
7	82	North Maluku	0,2490	**Low Social Vulnerability Groups**			
8	72	Central Sulawesi	0,2110	25	14	Riau	-0,1910
9	35	East Java	0,1735	26	15	Jambi	-0,2474
10	11	Aceh	0,1695	27	71	North Sulawesi	-0,2541
Middle Social Vulnerability Groups				28	65	North Kalimantan	-0,2650
11	18	Lampung	0,1173	**Very Low Social Vulnerability Groups**			
12	91	West Papua	0,0614	29	64	East Kalimantan	-0,4986
13	61	West Kalimantan	0,0292	30	21	Riau Islands	-0,6404
14	74	Southeast Sulawesi	0,0228	31	19	Bangka Belitung Islands	-0,7227
15	12	North Sumatera	0,0036	32	31	DKI Jakarta	-0,7755
16	16	South Sumatera	0,0012	33	34	DI Yogyakarta	-0,8164
17	13	West Sumatera	-0,0006	34	51	Bali	-0,8429

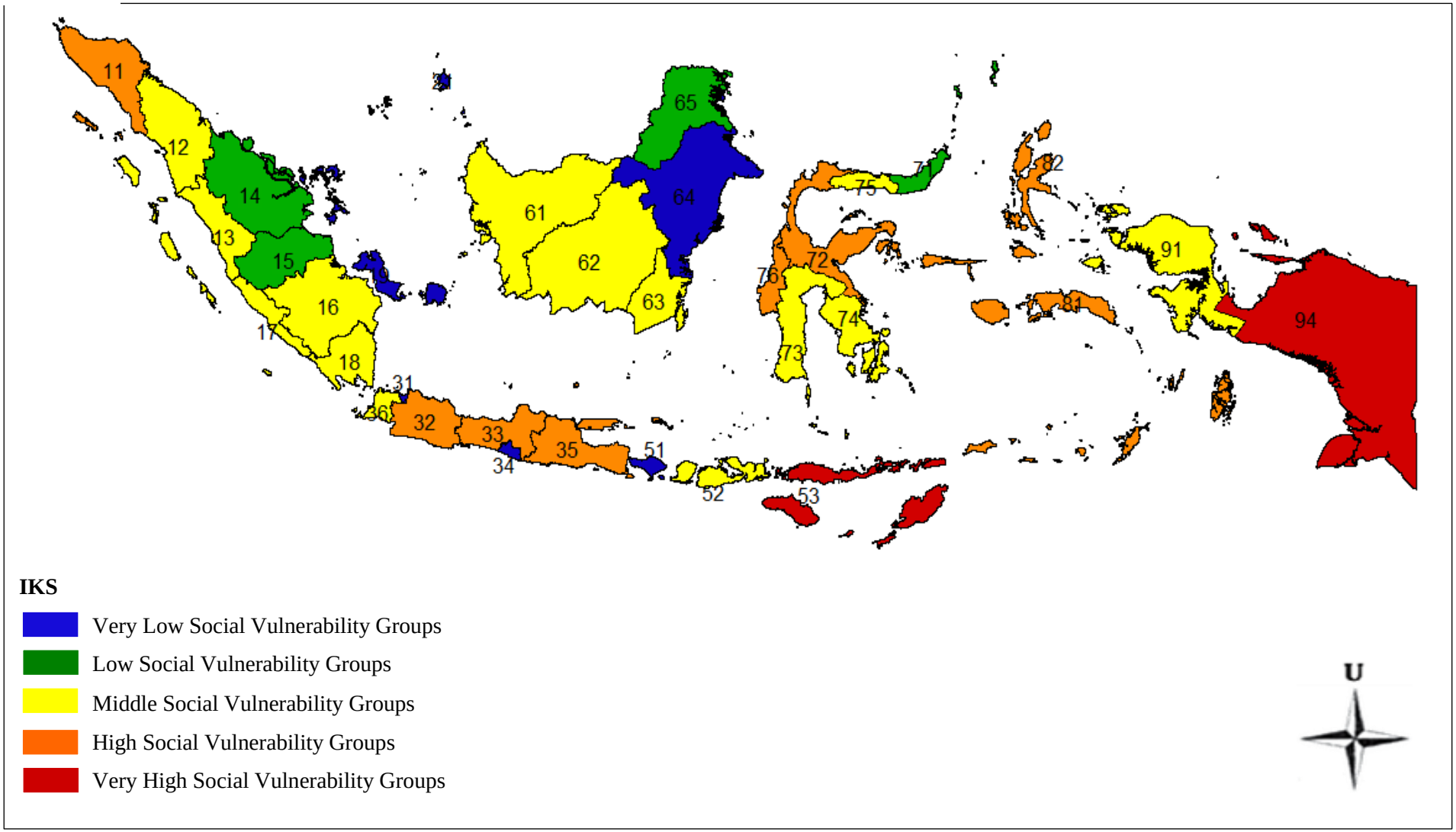

Fig. 2. Variations in the level of social vulnerability between provinces in Indonesia based on IKS

4. CONCLUSION

From the 14 research variables extracted by the PCA method, four factors were generated: housing and exposure of smoke factor, economic factor, social demographic factor and welfare factor. The four factors can explain the variation in social vulnerability to tuberculosis by 73.40 percent.

The level of social vulnerability to tuberculosis can be measured by the Social Vulnerability Index of Tuberculosis (IKS) which is a composite index with components: housing and exposure of smoke factor (weight 0.459), economic factor (weight 0.250), social demographic factor (weight 0.167), and welfare factor (weight 0.124).

From the results of IKS calculations for all provinces, the level of social vulnerability to tuberculosis in Indonesia can be grouped into: 6 provinces in very low social vulnerability group, 4 provinces in low social vulnerability group, 14 provinces in middle social vulnerability group, 8 provinces in high social vulnerability group, and 2 provinces in very high social vulnerability group.

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