Prediction Model of Food Security on Heart Disease Incidence in Indonesia

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ABSTRACT
Food security is one of main health problems in Indonesia. Previous studies have shown a correlation between food insecurity and heart disease, but it cannot be predicted whether food insecurity is a risk factor for heart disease. **Purpose**. This study aims to determine the relationship between food insecurity and incidence of heart disease among Indonesian aged 15–65 years in a cohort over 14 years. **Method.** The subjects were 13,464 Indonesian residents aged 15–64 years. Subjects were followed for 14 years to find out the incidence of heart disease.To reveal relationship between two variables above, General Structural Equations Model (GSEM) was used. **Results** : from GSEM analysis indicate that food security status is indirectly related to the incidence of heart disease. Food insecurity increases risk of overweight and hypercholesterolemia by 0.18 and 0.55 units respectively compared to food insecurity status. Excess body weight and hypercholesterolemia become mediators between food security and hypertension, stroke, and diabetes mellitus. Direct causal factors ($p<0.004$) of heart disease in Indonesian population are old age (43–65 years), stroke, hypertension, and diabetes mellitus. **Conclusion**. Food safety status is indirectly related to heart disease. Obesity, diabetes mellitus, and hypertension are mediators between food security status and heart disease.

Introduction:

Food insecurity is a social and economic condition of families experiencing limitations or uncertainty in obtaining adequate food, which is characterized by a reduction in the quality, variety, or choice of desired food . Food insecurity is one of the main health problems in developing countries like Indonesia. The Ministry of Agriculture's Food Security Agency reported that 71 districts (17.1%), 5 cities (5.1%), and 6 provinces (17.6%) had a low food security index and needed to be given priority of comprehensive food insecurity treatment. A low food security index describes a deficiency in food availability, food affordability/access, and/or food utilization. This condition is in line with the World Food Program (WFP) report which states that Indonesia is still facing the problem of food insecurity, in terms of its

availability, access, intake, and utilization, such as the still high proportion of carbohydrates as an energy source, low consumption of vegetables and fruit, unequal distribution clean and safe water supply, relatively high rice prices, and still high dependence on imports of meat, sugar, and soybeans

Food insecurity can increase the risk of chronic diseases such as diabetes mellitus, hypertension, stroke, asthma, arthritis, cancer, kidney disease, hepatitis, heart disease (Laraia, 2012), and cardiovascular disease . Previous research reported that there had been a correlation between food insecurity and various risk factors for heart disease such as dyslipidemia, metabolic syndrome, diabetes mellitus, hypertension, lack of physical activity, obesity, smoking, and lack of fruit and vegetable consumption (Faramarzi, Somi, Ostadrahimi, Dastgiri, & Nahand, 2019). A study in the United States also found that adults with food insecurity had a higher possibility of experiencing cardiovascular disease within the course of 10 years, had a higher risk of increased systolic blood pressure, a higher body mass index, and a higher likelihood of smoking compared to adults with full security food (Vercammen et al., 2019). A systematic review of 11 articles conducted by Miguel et al., also concluded that food insecurity is directly related to cardiometabolic risk factors, especially overweight, hypertension, and dyslipidemia.

Although previous studies have shown that there is a relationship between food insecurity and the risk of cardiovascular disease and heart disease, they cannot predict whether food insecurity is a risk factor for heart disease, or vice versa, whether heart disease is a risk factor for food insecurity. The results of the systematic review of 14 articles on the relationship between food insecurity and cardiovascular disease published from 2010 to 2020 only found 1 research article with a cohort design. Cohort research is very important to conduct because cross-sectional studies cannot conclude the direction of the relationship between food insecurity and heart disease. Therefore, this study aims to find out the effect of food insecurity on the incidence of heart disease and its risk factors (namely, obesity, diabetes mellitus, hypertension, depression, hypercholesterolemia, and stroke), in the 15–65 years of age, of Indonesian population in a cohort of 14 years.

Material and Methods:

This research uses a retrospective cohort design using secondary data from the Indonesia Family Life Survey (IFLS) in 2000, 2007, and 2014. The sample used in this research was 13,464 Indonesian residents aged 15–64 years contained in the 2000 survey data, who meet the inclusion criteria 1) have food consumption data, 2) do not suffer from serious diseases such as hypertension, diabetes mellitus, and liver disease, 3) have never been diagnosed with heart disease before 2000, 4) are recorded in the 2000 and 2014 IFLS.
Food insecurity status was determined based on the consumption of 10 types of food during the 7 days before the survey. The steps in determining food insecurity status are: 1) calculating the consumption score for each type of food, 2) grouping food types into 5 groups: staple food group; meat, egg, and fish group; milk group; vegetable group; and fruit groups, 3) calculate the consumption score of food groups by adding up the scores for each type of food contained in the group. The sum of each food group is then multiplied by the value amount as follows: 2 for the staple food group, 4 for the fish, eggs, and meat group, 4 for the milk group, 1 for the vegetable group, and 1 for the fruit group. 4) Calculate the food consumption score by adding up the results of multiplying the food group consumption scores with value numbers. 5) Determine food insecurity status as follows: labeled as not food insecurity if the food consumption score is more than 35, and food insecurity if the food consumption score is less than or equal to 35(1).

The determination of the type of disease is based on the respondent's answer to the question "Has any doctor/paramedic/nurse/midwife ever told you that you have (...)?" Which includes 1) heart attack, coronary heart disease, angina, or other heart disease; 2) diabetes (high blood sugar); 3) stroke; 4) high blood pressure and 5) cholesterol. If a participant reported experiencing any of those outcomes, they would be given such question: "When was the condition (…) first diagnosed? This includes the year and/or age they were first diagnosed. Participants who had been diagnosed with heart disease before 2000 were excluded from the study.

Depression status is determined by giving a score to the respondent's answers to 8 questions about signs of depression during the last 4 weeks. Score 0 for "never", 3 for "sometimes" and 4 for "often". The scores for each question are then added up. Respondents are declared as depressed if the total score is >9, and not depressed if ≤9(2).

The bivariate analysis used to reveal the correlation between risk factors and the incidence of heart disease is Chi-square. To find out the path of the relationship between independent variables and the incidence of heart disease, path analysis, namely the General Structural Equations Model (GSEM), was used. To determine the best model, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) are used.

Results and Discussion

Bivariate Analysis Results

The bivariate analysis results can be seen in Table 1, which shows the factors associated with the incidence of heart disease. From Table 1 it can be seen that food security status, old age, obesity, hypertension, major depression, stroke, and hypercholesterolemia increase the risk of heart disease significantly (p<0.05).

Table 1. Results of bivariate analysis of factors associated with heart disease.

Independent variable	OR	CI 95%		p
		Lower limit	Upper limit	
Sex				
Female	Ref.			
Male	0.89	0.69	1.14	0.346
Age (year)				
15–22 year	Ref.			
23–42 year	2.87	1.80	4.56	<0.001
43–65 year	5.65	3.54	9.01	<0.001
Housing				
Rural	Ref.			
Urban	1.34	1.05	1.72	0.018
Food security				
Insecurity	Ref.			
Security	1.39	1.08	1.78	0.011
Body mass index				
Underweight	Ref.			
Normal weight	1.22	0.81	1.83	0.333
Overweight	1.68	1.03	2.72	0.036
Obesity stage 1	2.58	1.65	4.02	<0.001
Obesity stage 2	4.97	2.81	8.78	<0.001
Hypertension				

No	Ref			
Yes	3.61	2.81	4.63	0.000
Depression				
Mild	Ref.			
Severe	1.33	1.01	1.77	0.047
Stroke				
No	Ref.			
Yes	4.72	2.74	8.12	<0.001
Hypercholesterolemia				
No	Ref.			
Yes	4.85	3.60	6.52	<0.001

Table 2 is the result of the Hypothesis Model path analysis, which shows that diabetes mellitus, smoking, depression, food insecurity, and gender do not have any direct impact on the incidence of heart disease. The occurrence of heart disease is directly influenced by hypertension, age, body mass index, and hypercholesterolemia. This table shows that the values for AIC = 51,179.27, and BIC = 51,344.74. Based on those results, the researchers then made a revised model, by eliminating the variables of gender, smoking, and depression. Table 6 is the result of the GSEM analysis of model re-specification, which shows that heart disease is directly influenced by hypertension (p=0.000), age (p=0.000), hypercholesterol (p=0.000), and body mass index (p=0.009).

Table 2. GSEM analysis result hypothesis model.

Pathway		Model for heart disease				
		Coefficient	Std. error	z	p-value	Confidence Interval
Directly						
Diabetes →	Heart disease	.265059	.2251295	1.18	0.239	-1761867 - .7063048
Hypertension		.8248209	138229	5.97	0.000	.5538971 - 1.095745
Smoking		.2856362	.1894304	1.51	0.132	-.0856406 - .656913
Depression		.2247565	.1472201	1.53	0.127	-.0637895 - .5133025
Food secure		.2082444	.1301134	1.60	0.109	-.0467732 - .4632621
Age		.5872057	.1019803	5.76	0.000	.3873279 - .7870834
Male		-.094379	.1810708	-0.52	0.602	-.4492712 - .2605132
BMI		.1555058	.0629731	2.47	0.014	.0320809 - .2789307
Hypercholesterolemia		1.050833	.16654	6.31	0.000	.7244203 - 1.377245

Indirectly						
Food secure →	Diabetes	.3589062	.0938525	3.82	0.000	.1749586 - 5428537
Food secure →	Hypertension	.0984742	.0458216	2.15	0.032	.0086654 - .1882829
Hypercholesterol		1.481789	.0737901	20.08	0.000	1.337163 - 1.626415
Food secure →	Depression	-.0017308	.0426273	0.04	0.968	-.0852789- 0818172
Food secure →	BMI	.1816094	.0454285	4.00	0.000	.0925713 - .2706476
Food secure →	Hypercholesterol	.4530245	.0761442	5.95	0.000	.3037846 - .6022644
BMI		.653295	.0323898	20.17	0.000	.5898121 - .7167779
Fixed model						
AIC (Akaike's Information Criteria)BIC (Bayesian Information Criteria		51179.27 51344.74				

Food security status is indirectly related to heart disease. Food security status directly influences the occurrence of hypercholesterolemia and overweight or obesity which directly influences heart disease. Food security status also has a direct influence on the occurrence of diabetes mellitus (p=0.000), diabetes mellitus influences the occurrence of hypertension. From Table 3 it is also known that the AIC and BIC values of the revised model are smaller than that of the AIC and BIC of the hypothesis model, therefore, the revised model is considered a fixed model.

Table 3. GSEM analysis results from model re-specification (fixed model)

Pathway		*Model for Heart Disease*				
		Coefficient	Std. error	z	p-value	Confidence Interval
Directly						
Hypertension →	Heart Disease	.8281772	.136593	6.06	0.000	.5604599 - 1.095894
Age		.6175065	.1006824	6.13	0.000	.4201726 - .8148403
BMI		.1572007	.0604171	2.60	0.009	.0387853 -.2756161
Hypercholesterolemia		1.096337	.1638579	6.69	0.000	.7751815 - 1.417493
Indirectly						
Food secure →	Diabetes	.2044485	.0965215	2.12	0.034	.0152698 - .3936272
BMI		.9143233	.0418706	21.84	0.000	.8322584 - .9963883
Diabetes →	Hypertension	1.156784	.0979226	11.81	0.000	.9648596 - 1.348709

Hypercholesterol		1.368195	.0754344	18.14	0.000	1.220347 - 1.516044
Food secure →	BMI	.1816087	.0454285	4.00	0.000	.0925706 - .2706469
Food secure →	Hypercholesterol	.4530245	.0761442	5.95	0.000	.3037846 - .6022644
BMI		.6532951	.0323898	20.17	0.000	.5898122 - .716778

Conformity test result

AIC (Akaike's Information Criteria):	36798.85
BIC (Bayesian Information Criteria:	36919.19

Discussion:

Hypertension, Diabetes, and Heart Disease in Indonesia

Table 3 shows an incline trend of the number of people who suffer from hypertension, diabetes mellitus, and heart disease in Indonesia. In the 2007 IFLS, hypertension cases were found at 7.59%, diabetes at 0.89%, and heart disease at 0.64%). This figure is lower than the results of the 2007 Basic Health Research, which showed that the national prevalence of hypertension in the population aged > 18 years was 29.8%, and diabetes mellitus was 1.1%. And heart disease 7.2% (3). In the 2014 IFLS, it was found that there had been an increase in hypertension cases to 17.87%, diabetes by 3.63%, and heart disease by 1.92%. These results are not much different from the results of the 2013 Basic Health Research which showed that the proportion of people suffering from hypertension based on interview results was 9.4%, diabetes, 2.1%, and coronary heart disease, 1.3% (4).

Food insecurity and heart disease

The results of the bivariate test, as shown in Table 4, show that individuals with food security status are 1.39 times more at risk of experiencing heart disease compared to individuals with food insecure status. These results are different from previous research which found that individuals with food insecurity have a greater risk of experiencing heart and cardiovascular disease (5)(6)(7)(8). The results of path analysis show that food security status influences the occurrence of heart disease indirectly but through several mediator variables.

Firstly, individuals with food security status increase the risk of being overweight and obese. These results are different from several previous studies, which stated that individuals with food insecurity status were at greater risk of obesity (9)(10)(11). Overweight and obesity occur when calorie consumption is greater than calories expended. Excess calories that come from carbohydrates or glucose, protein, and fat will be stored in the form of glycogen and triglyceride (fat) thereby causing weight gain (12). Subjects with food-secure status consumed more amount of carbohydrates and meat than food-insecure subjects. Research in Iran (13), research in America (14), and research in Bogor, Indonesia (15) concluded that a higher intake of processed meat increases the risk of central obesity, while white meat intake increases the risk of obesity. Processed meat contains higher levels of obesogenic substances, such as fat, nitrosamines, and sodium . Food-secure individuals generally have a better economic status, which can be associated with low physical activity, smoking habits, alcohol consumption, and

unhealthy diet patterns. Therefore, many food-secure individuals experience obesity and metabolic syndrome (16).

Being overweight causes insulin resistance and increases blood sugar levels (glucotoxicity). Glucotoxicity can accelerate pancreatic beta cell apoptosis directly or by stimulating the formation of pancreatic beta cell immunogens and auto-immune reactions. (17) Obesity is also considered a trigger for insulin resistance found in type 2 diabetes patients. In individuals with obesity problems, there is an increase in the secretion of hormones, glycerol, leptins, adipose, nectines, proinflammatory substances, and non-esterified fatty acids (NEFAs) from adipose tissue. High levels of NEFAs cause disturbances in glucose-stimulated insulin secretion, decreased insulin biosynthesis, and insulin resistance (18).

Diabetes mellitus is a direct risk factor for heart disease, especially myocardial infarction (MI). Previous research found that DM causes an escalation of expression of glycoprotein IIB/IIIA receptors and VWF, escalation of plasminogen activator inhibitor type 1, and decline of anti-coagulants which puts DM patients at greater risk of MI due to thrombosis and coagulation in the coronary arteries. (19) Hyperglycemia in DM patients is also considered to have the potential of increasing protein glycation in the arterial wall, elevating Reactive Oxygen Species, and decreasing Nitric Oxide synthesis. These conditions cause DM patients to be more at risk of coronary heart disease due to atherosclerosis and plaque formation in the coronary arteries. (20)

Secondly, food safety status increases the risk of hypercholesterolemia. Food-secure individuals consume more meat, milk, and eggs, while meat and eggs contain high levels of saturated fatty acids. Research in Korea found that the intake of saturated fatty acids and trans fats increases the risk of hypercholesterolemia in women. (21) Apart from consumption of saturated fatty acids and trans fats, hypercholesterolemia is also caused by genetic factors and lack of physical activity (22).

Hypercholesterolemia has long been known as a risk factor for heart disease. Hypercholesterolemia decreases coronary blood flow reserve and capillary density, induces apoptosis of capillary endothelial cells, and ultimately leads to impaired left ventricular function. Hypercholesterolemia is expected to impact changes in the membrane lipid bilayer, regulation of intracellular calcium ions, and expression patterns of myosin heavy chain isoforms, making the myocardium more sensitive to exogenous damage (such as high blood pressure, myocardial ischemia, diabetes). (23)

In this study, it is known that hypercholesterolemia influences the occurrence of heart disease through hypertension as a mediator. Several theories explain the relationship between hypercholesterolemia and hypertension, including 1) hypercholesterolemia causes reduced synthesis of Nitric Oxide (NO), 2) hypercholesterolemia increases microvascular vasoconstriction, 3) hypercholesterolemia may affect blood-brain barrier integrity by increasing the expression of tight junction proteins, leading to the production of vascular endothelial growth factor. (24) Previous research found that controlling hypertension can reduce the risk of cardiovascular disease by 20–40%, however, if controlling hypertension is accompanied by reducing cholesterol levels, it can reduce the risk of cardiovascular disease by up to 50%. (25) Research conducted by Porecel-Rodrigues et al. al., (2003) also found that the combination of HC and HT for 12 weeks caused a decrease in myocardial perfusion and microvascular permeability response to cardiac workload. These functional disturbances are associated and correlated with marked changes in systemic and myocardial oxidative status, LDL oxidizing ability, and clearance activity (26).

Risk Factors for Heart Disease in Indonesia

Gender and heart disease

Men have a 0.89 lower risk of experiencing heart disease than women, but this is not statistically significant (OR= 0.89; 95% CI= 0.69 to 1.14; p= 0.346. The influence of gender differences on the incidence of heart disease and other cardiovascular diseases is influenced by heredity and environmental factors (27). In general, women have a greater risk than men, especially after menopause. Women have specific risk factors for heart disease such as premature birth, gestational diabetes, hypertension in pregnancy, and menopausal transition. (28)(29)

Age and heart disease

Table 4 shows that respondents who are 43–65 years old have a higher risk of 5.65 times to experience heart disease compared to those aged 15–22 years. The aging process is associated with decreasing cardiovascular function which is responsible for the elevating risk of heart disease. The aging process in the cardiovascular system causes cardiac hypertrophy, changes in left ventricular (LV) diastolic function, decreased LV systolic return capacity, arterial stiffness, and impaired endothelial function (30). The prevalence of heart failure generally doubles every decade of life. The prevalence is <1% in the age group <40 years, and >10% in the age group >80 years. At the ages of 40 and 80 years, both men and women have a lifetime risk of heart failure at around 20%. (31).

Housing and heart disease

Table 4 shows that living in urban areas increases the risk of heart disease by 1.34 times compared to living in rural areas and is statistically significant (OR= 1.34; 95% CI= 1.05 to 1.72; p= 0.018). These results are in line with research by Sigiharto et al., which found that men who live in urban areas are 1.4 times more likely to experience heart disease than those who live in rural areas and elderly people who live in urban areas are at 1.9 times greater risk of experiencing heart disease compared to those living in rural areas (32) and research by Eissen et al., in Nigeria. (33) Characteristics of rural communities in general still respect traditional customs, characterized by being physically active, consuming more natural foods, and lower psychological stress. (34)

Smoking and heart disease

The results of the bivariate test (table 4) show that smoking increases the risk of heart disease by 1.07 times compared to not smoking, but it is not statistically significant (OR=.1.07, 95% CI=0.83 to 1.39, p= 0.587). Meanwhile, in the GSEM analysis, it was found that smoking influences the incidence of heart disease indirectly, which is through stroke. Smoking is a classic risk factor for heart and blood vessel disease. The chemical content in cigarette smoke is expected to cause damage to the blood vessel endothelium and decrease the synthesis and bioavailability of nitric oxide which disrupts the regulation of blood vessel dilation and constriction (35)(37). Smoking is also known to increase the risk of obesity, which is a risk factor for cardiovascular disease (38) (39).

Stroke and heart disease

Table 4) shows that stroke increases the risk of heart disease by 4.72 times compared to not having a stroke and is statistically significant (OR= 4.72; 95% CI= 2.74 to 8.12; p<0.001). Stroke and heart disease are cardiovascular diseases and have almost the same risk factors. A review conducted by Polednid, et al. found that 48%–70% of stroke survivors who had no

previous history of heart disease experienced coronary plaque and 30.9% experienced significant coronary artery stenosis (at least 50%) in at least one branch of the artery. (40) The results of this study are in line with Rohit's research (2019) which concluded that coronary heart disease is commonly found in stroke patients, but the mechanism is not yet clearly known. (41)

Kidney disease and heart disease

The results of our study (table 4) show that kidney disease increases the risk of heart disease by 4.91 times compared to not having kidney disease and is statistically significant (OR= 4.91; 95% CI= 3.02 to 7.98; p <0.001). The correlation between kidney disease and heart disease can be explained through several mechanisms as follows: 1) Patients with kidney disease generally have traditional heart disease risk factors, such as hypertension, diabetes mellitus, and hyperlipidemia, 2) Kidney failure can cause calcification of the arteries, and increase the workload of the heart, 3) Kidney failure causes myocardial fibrosis accompanied by collagen deposition between the capillaries and heart muscle cells, 4) Kidney failure triggers inflammation and atherosclerosis. (42)

Digestive diseases and heart disease

The results of this study show that digestive disease increases the risk of heart disease by 2.54 times compared to not having digestive disease and is statistically significant (OR= 2.54; 95% CI= 1.91 to 3.37; p<0.001). A literature review conducted by Gesualdo, et al., (2016) concluded that gastro-esophageal reflux disease and inflammatory bowel disease can be associated with heart rhythm abnormalities and atrial fibrillation. Sundaram and Fang (2016) explained that Protein-Losing Enteropathy can cause increased right heart filling pressure, constrictive pericarditis, and tricuspid valve regurgitation. (43)

Conclusion:

From GSEM analysis indicate that food security status is indirectly related to the incidence of heart disease. Food insecurity increases risk of overweight and hypercholesterolemia by 0.18 and 0.55 units respectively compared to food insecurity status. Excess body weight and hypercholesterolemia become mediators between food security and hypertension, stroke, and diabetes mellitus. Direct causal factors (p<0.004) of heart disease in Indonesian population are old age (43–65 years), stroke, hypertension, and diabetes mellitus.Food security status is indirectly related to the incidence of heart disease in Indonesia. Being overweight or obese, and suffering from diabetes mellitus and hypertension are mediators of the relationship between food security status and heart disease. Performing a healthy diet and lifestyle is vital for food-secure individuals to reduce the risk of heart disease.

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Conflict of interest:

There is no conflict of interest in this research

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