TWO DECADES OF CHANGE IN ISCHEMIC HEART DISEASE BURDEN IN INDONESIA BASED ON RISK FACTORS

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ABSTRACT

The burden of ischemic heart disease (IHD), measured in disability-adjusted life years (DALYs), has significantly increased in Indonesia over the past two decades, indicating that current policies and programs have not been fully effective. This study aimed to analyze changes in the burden of IHD and its associated risk factors from 2002 to 2021 across 34 provinces in Indonesia, using secondary data from the Global Burden of Disease 2021. This cross-sectional analytical study used IHD-related DALYs as the dependent variable, and independent variables included non-optimal temperature, low physical activity, tobacco use, risky dietary patterns, air pollution, obesity, hypertension, high LDL cholesterol, and high fasting glucose. Descriptive statistics and linear regression were used, with Principal Component Analysis (PCA) applied to reduce multicollinearity. Separate regressions were conducted for 2002 and 2021 to assess changes over time. The results showed a 10.5% increase in IHD-related DALYs, from 2,753.87 per 100,000 population in 2002 to 3,043.08 in 2021. Hypertension emerged as the leading risk factor, followed by risky dietary patterns. Tobacco use and a principal component (low physical activity, risky dietary patterns, obesity, high LDL cholesterol, hypertension, and high fasting glucose) significantly contributed to the burden of IHD in both years. Environmental factors such as non-optimal temperature and air pollution did not show significant effects. Health programs must be strengthened with a focus on seven key risk factors contributing to IHD-related DALYs, especially modifiable ones like low physical activity, risky dietary patterns, and tobacco use to reduce IHD burden in Indonesia.

Keywords: Ischemic Heart Disease, Disability-Adjusted Life Years, Risk Factors, Global Burden of Disease

ABSTRAK

Beban penyakit jantung koroner (PJK), yang diukur dengan tahun hidup disesuaikan dengan disabilitas (DALYs), mengalami peningkatan signifikan di Indonesia selama dua dekade terakhir. Hal ini menunjukkan bahwa kebijakan dan program yang telah diterapkan belum sepenuhnya efektif. Penelitian ini bertujuan untuk menganalisis perubahan beban PJK dan faktor-faktor risikonya dari tahun 2002 hingga 2021 di 34 provinsi di Indonesia menggunakan data sekunder dari Global Burden of Disease 2021. Studi ini merupakan penelitian analitik cross-sectional dimana DALYs akibat PJK sebagai variabel dependen. Variabel independen meliputi suhu tidak optimal, aktivitas fisik rendah, konsumsi tembakau, pola diet berisiko, polusi udara, obesitas, hipertensi, kolesterol LDL tinggi, dan glukosa puasa tinggi. Analisis data terdiri dari analisis deskriptif dan regresi linier, Principal Component Analysis (PCA) diterapkan untuk mengatasi multikolinearitas. Analisis regresi menggunakan data tahun 2002 dan 2021. Hasil menunjukkan peningkatan DALYs akibat PJK sebesar 10,5%, dari 2.753,87 per 100.000 penduduk pada tahun 2002 menjadi 3.043,08 pada tahun 2021. Hipertensi menjadi faktor risiko utama, diikuti oleh pola diet berisiko. Konsumsi tembakau dan komponen utama yaitu gabungan enam faktor risiko (aktivitas fisik rendah, pola diet berisiko, obesitas, kadar LDL tinggi, hipertensi, dan glukosa puasa tinggi) berpengaruh terhadap beban PJK pada kedua tahun. Faktor lingkungan yaitu suhu tidak optimal dan polusi udara tidak menunjukkan

pengaruh terhadap beban PJK. Program kesehatan perlu diperkuat dengan menitikberatkan pada tujuh faktor risiko utama yang berkontribusi terhadap DALYs akibat PJK khususnya faktor yang dapat dimodifikasi seperti rendahnya aktivitas fisik, pola diet berisiko, dan konsumsi tembakau untuk menurunkan beban PJK di Indonesia.

***Kata kunci**: Penyakit Jantung Koroner, Tahun Hidup Disabilitas, Faktor Risiko, Global Burden of Disease*

INTRODUCTION

Over the past 30 years, the burden of infectious diseases has significantly decreased, while the burden of noncommunicable diseases has increased to some extent (1). The burden of disease can be measured using metrics such as incidence, prevalence, mortality, years of life lost (YLL) and years lived with disability (YLD) (2). The standard metric commonly used to provide a comprehensive estimate of disease burden is disability-adjusted life years (DALY), which combines both YLD and YLL components (3). YLL represents years of life lost due to premature mortality, and YLD signifies years lived with disability (4). DALYs provide a more comprehensive overview of a disease's impact on a population through the integration of mortality and morbidity aspects (5).

Ischemic heart disease (IHD) is one of the most common non-communicable diseases (NCDs) and remains a leading cause of death and disability worldwide (6). According to data from Global Burden of Disease (GBD) 2019, approximately 18,050,671 young adults worldwide were affected by IHD that year, resulting in 28,692,968 DALYs. This represents about 9.15% of total global IHD cases and 15.7% of total IHD-related DALYs (7). By 2050, it is projected that IHD-related DALYs will reach 302 million (8).

A wide range of policies and programs have been implemented by the Indonesian government in an effort to control non-communicable diseases (NCDs), including IHD. These initiatives include the Strategic Plan for Non-Communicable Disease Control 2015–2019, *Gerakan Masyarakat Hidup Sehat* (GERMAS) launched in 2016, as well as the smoke-free zone policy and tobacco control measures initiated in 2009 and continuing to the present. In addition, following the COVID-19 pandemic, home-based healthcare service programs utilizing smartphones and internet technology have been developed to improve access to health services and consultations (9).

However, Indonesia has the second-highest rate of DALYs due to cardiovascular disease in ASEAN, following Laos. The highest DALYs rates for cardiovascular disease at the provincial level are observed in Bangka Belitung, South Kalimantan, and Yogyakarta (10). According to GBD 2021 data, IHD remains the second leading cause of DALYs in Indonesia, with a 10.5% increase over the past two decades from 2,753.87 in 2002 to 3,043.08 in 2021 (11).

Previous Global Burden of Disease studies have identified significant risk factors for IHD-related DALYs including high LDL (low-density lipoprotein) cholesterol, high fasting glucose, tobacco use, hypertension, high body mass index (BMI), risky dietary patterns, and air pollution (12)(2). Observational studies show that the temperature and cardiovascular disease burden relationship often follows a U or J shaped pattern, where both cold and heat beyond the optimal range increase cardiovascular risk. Biologically, this can be explained by sympathetic activation, vascular tone changes, increased cardiac workload, and inflammatory and pro-thrombotic responses, which together can trigger ischemia or destabilize atherosclerotic plaques (13).

The increase in IHD-related DALYs over the past two decades (2002–2021)

indicates that the policies and programs implemented have not been fully effective in reducing the burden of IHD. Therefore, a more in-depth investigation is needed to examine the changes in the burden of IHD and its associated risk factors in Indonesia over the last 20 years.

Previous studies have only focused on the burden of cardiovascular disease in Indonesia in general up to 2019, and have not specifically analyzed the burden of IHD and its risk factors by province in Indonesia using the latest 2021 data (14)(15). This study aims to analyze the changes in the burden of IHD (DALYs Lost) and its associated risk factors in Indonesia over the last 20 years (2002–2021).

METHODS

This research adopts an analytical observational approach with a cross-sectional design, employing secondary data obtained from the Global Burden of Disease (GBD) 2021 study. Data from GBD study, obtained through proposal submission to the Institute for Health Metrics and Evaluation (IHME) and accessed via https://vizhub.healthdata.org/gbd-results/. The data extracted spans the last 20 years, from 2002-2021. In this study, all data utilize age-standardization and include all genders to mitigate bias resulting from differences in demographic structure among provinces in Indonesia.

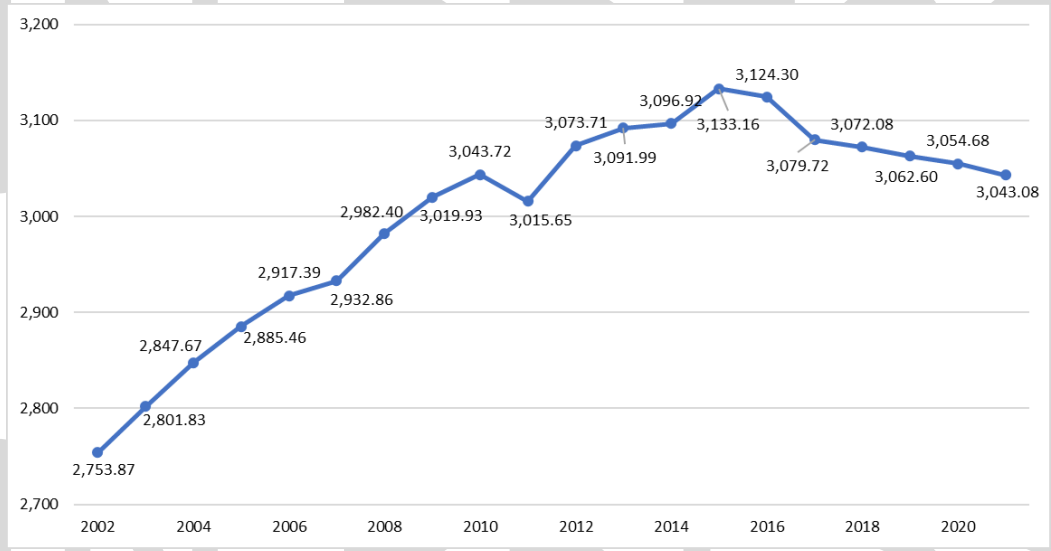
The unit of analysis is the province, with a total sample of 34 provinces in Indonesia. The dependent variable in this study is IHD-related DALYs. The independent variables include non-optimal temperature, low physical activity, tobacco use, risky dietary patterns, air pollution, obesity, hypertension, high LDL cholesterol, and high fasting glucose. All variables were measured in rates per 100,000 population. The rate metric was chosen because the unit of analysis in this study is the province. Rate describes the frequency of events in a population over a specific time period, making it suitable for measuring the magnitude of health problems based on place and time (16). Ethical approval for this research was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Airlangga, with approval number 120/EA/KEPK/2025.

Data analysis included descriptive statistics and linear regression analysis. Descriptive analysis was presented in the form of graphs to observe trends of each variable from 2002 to 2021. The graphic includes IHD-related DALYs in Indonesia, showing the provinces with the highest and lowest values in 2002 and 2021. The graphic also presents the provinces with the highest and lowest proportions of each independent variable.

Linear regression was then conducted using data from two time points, 2002 and 2021, to examine changes in the influence of the independent variables on IHD-related DALYs over the past two decades. PCA (Principal Component Analysis) analysis was performed to address the unmet assumption of multicollinearity by reducing six correlated variables, namely low physical activity, risky dietary patterns, obesity, high LDL, hypertension, and high fasting glucose, into a single principal component (PC). Stata version 17 and Microsoft Excel were the software programs used to conduct the data analysis in this study.

RESULTS

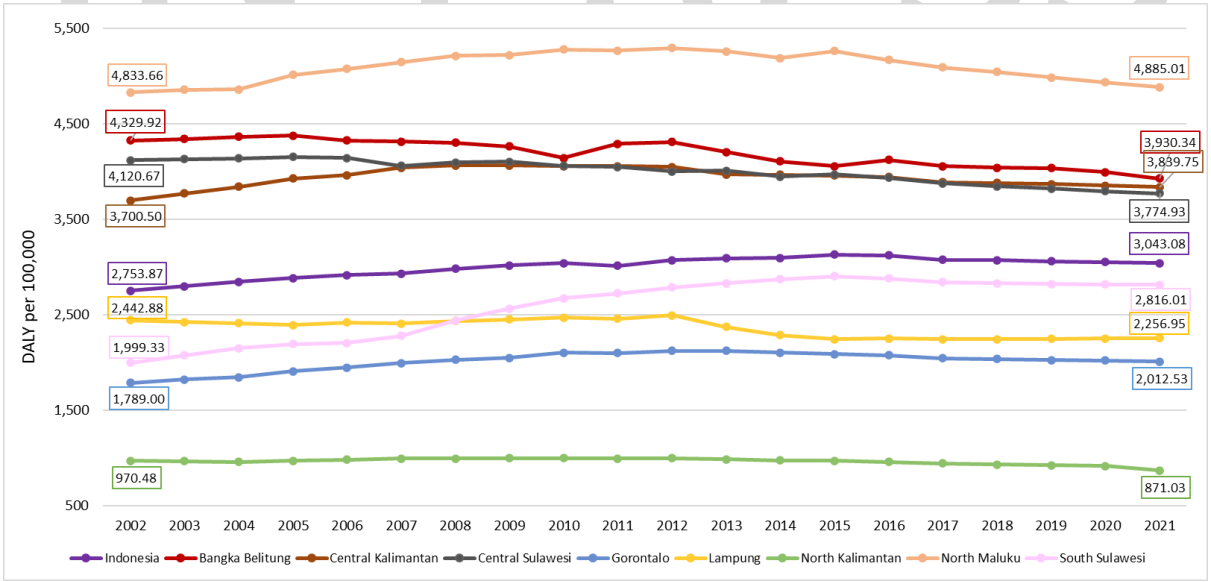
The burden of IHD in Indonesia, measured in DALYs lost, increased by 10.5% over the two-decade period from 2002 to 2021. The IHD-related DALYs were 2,753.87 per 100,000 population in 2002, increasing to 3,043.08 per 100,000 in 2021 (Figure 1). The year 2015 recorded the highest burden of cardiovascular disease in Indonesia over the past 20 years, reaching 3,133.16 per 100,000 population.



Source: GBD 2021

Figure 1. IHD Burden Diagram (DALYs Lost) per 100,000 Population

The provinces with the highest and lowest IHD-related DALYs over the two decades from 2002 to 2021 have remained the same. North Maluku recorded the highest DALYs in both 2002 (4,833.66 per 100,000) and 2021 (4,885.01 per 100,000). In contrast, North Kalimantan consistently had the lowest DALYs, with 970.48 per 100,000 in 2002 and 871.03 per 100,000 in 2021 (Figure 2). Bangka Belitung consistently ranked as the second highest in IHD-related DALYs, while Gorontalo ranked as the second lowest. However, the third-highest and third-lowest rankings have changed, Central Sulawesi (2002) has been replaced by Central Kalimantan (2021) for the third-highest ranking, and South Sulawesi (2002) has been replaced by Lampung (2021) for the third-lowest ranking. South Sulawesi recorded the highest increase in IHD-related DALYs at 40.85%.

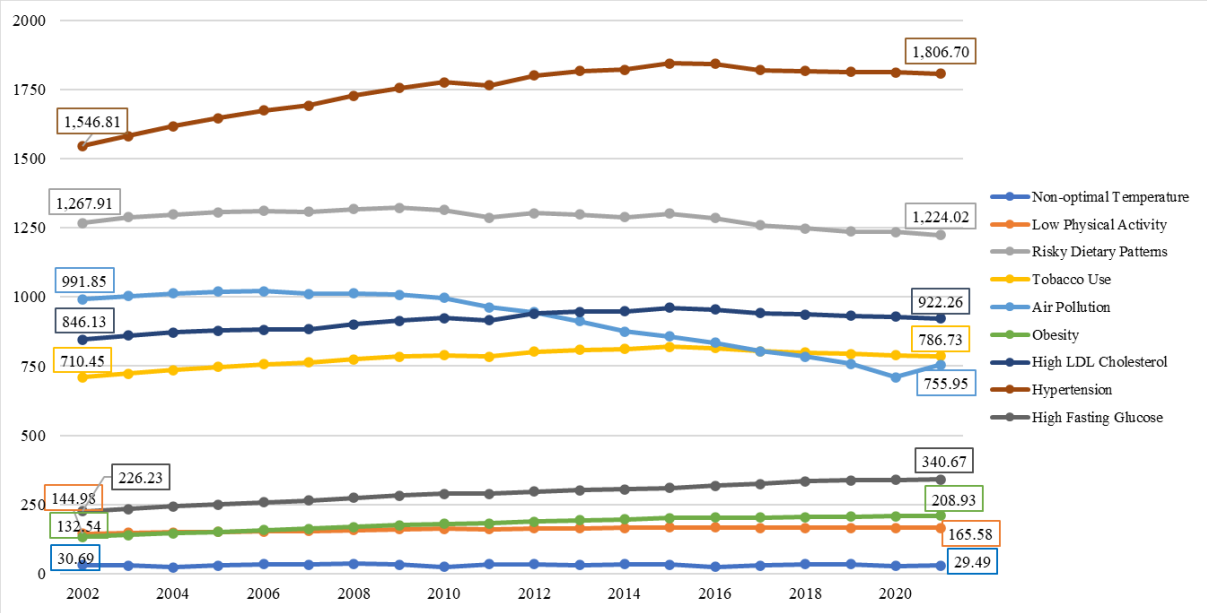


Source: GBD 2021

Figure 2. IHD Burden Diagram (DALYs Lost) by Province in Indonesia

The highest risk factor for IHD burden (DALYs Lost) in Indonesia is hypertension, followed by risky dietary patterns over two decades (2002-2021). Air

pollution was the third highest risk factor after hypertension and risky dietary patterns in 2002, and became the third highest risk factor in 2021. Meanwhile, non-optimal temperature was the lowest risk factor over the two decades. Low physical activity and obesity ranked as the third and second lowest risk factors for IHD-related DALYs after non-optimal temperature in both 2002 and 2021 (Figure 3).



Source: GBD 2021

Figure 3. Diagram of Risk Factor Proportion of IHD Burden (DALYs Lost) per 100,000 population

The effect of independent variables on IHD-related DALYs was analyzed using multiple linear regression. Several basic assumptions must be met in linear regression analysis, namely normality, linearity,autocorrelation, homoscedasticity, and multicollinearity. Six variables (low physical activity, risky dietary patterns, obesity, high LDL cholesterol, hypertension, and high fasting glucose) were reduced to a single factor called PC (principal component) using Principal Component Analysis (PCA), a technique used to transform a set of correlated variables into a number of uncorrelated principal components in order to address multicollinearity (17). The normality test employed the skewness-kurtosis method, where a *p-value* greater than 0.05 indicates that the residuals are normally distributed (Table 1). Linearity was tested using analysis of variance (ANOVA), where a *p-value* less than 0.05 indicates a linear relationship between the dependent and independent variables (Table 2).

Table 1. Normality Test Results

Year	*p-value*	
	Skewness	Kurtosis
2002	0,78	0,93
2021	0,87	0,18

The Durbin-Watson values for the 2002 and 2021 data are 2.02 and 2.18, respectively. These values are close to 2, indicating no autocorrelation in the residuals. Meanwhile, the results of the Breusch-Pagan test show *p-values* greater than 0.05, suggesting that there is no heteroscedasticity in the data, and thus the assumption of homoscedasticity is satisfied (Table 3).

Table 2. Linearity Test Results

Year	*p-value*
2002	0,00
2021	0,00

The results of the multicollinearity test indicated that all independent variables had Variance Inflation Factor (VIF) values less than 10, suggesting the absence of multicollinearity (Table 4). The five classical assumptions of linear regression were satisfied, allowing for the use of multiple linear regression analysis to analyze the effects of the independent variables on the dependent variable.

Table 3. Homoscedasticity Test Results

Year	*p-value*
2002	0,00
2021	0,00

Table 5 shows that in 2002, tobacco use and the principal component representing a combination of six independent variables had a significant effect on IHD-related DALYs in Indonesia. Consistent results were observed in 2021, where both tobacco use and the principal component significantly influenced IHD-related DALYs. The principal component had the highest coefficient in both years, suggesting that the combined effect of the six variables had a substantial impact on the burden of IHD in Indonesia.

Table 4. Multicollinearity Test Results

Variable	Year	
	2002	2021
Non-optimal Temperature	1,36	1,06
Tobacco Use	4,04	3,75
Air Pollution	5,65	2,78
Principle Component (low physical activity, risky dietary patterns, obesity, high LDL cholesterol, hypertension, high plasma glucose)	7,32	5,90

Table 5. Results of Multiple Linear Regression Analysis of Independent Variables on IHD-related DALYs in Indonesia

2002				
Independent Variable	**Unstandardized Coef**		**t**	***p-value***
	B	**Std.error**		
Non-optimal Temperature	0,82	0,69	1,20	0,24
Tobacco Use	1,05	0,13	8,13	0,00
Air Pollution	0,13	0,10	1,37	0,18
Principle Component (low physical activity, risky dietary patterns, obesity, high LDL cholesterol, hypertension, high fasting glucose)	230,19	16,55	13,91	0,00
2021				
Independent Variable	**Unstandardized Coef**		**t**	***p-value***
	B	**Std.error**		
Non-optimal Temperature	1,06	0,81	1,32	0,19
Tobacco Use	0,93	0,16	5,93	0,00
Air Pollution	0,11	0,10	1,16	0,26
Principle Component (low physical activity, risky dietary patterns, obesity,	223,76	17,64	12,68	0,00

Independent Variable	2021			
	Unstandardized Coef		t	*p-value*
	B	Std.error		
high LDL cholesterol, hypertension, high fasting glucose)				

DISCUSSION

According to the GBD 2021 study, the burden of IHD measured in DALYs, has increased in Indonesia over the past two decades, from 2002 to 2021. Previous research using GBD 2019 data showed that IHD was the second largest contributor to DALYs based on age-standardized rates, after stroke, in Indonesia (10). In contrast to Indonesia, global DALYs due to cardiovascular diseases (CVDs) decreased from 3,107.61 per 100,000 population in 1990 to 2,212.16 per 100,000 population in 2021 (18).

The risk factors for IHD-related DALYs can be categorized into three main groups: metabolic, behavioral, and environmental factors. The identified risk factors include low physical activity, tobacco use, risky dietary patterns, obesity, hypertension, high LDL cholesterol, high fasting glucose, non-optimal temperature, and air pollution. Previous GBD studies in Indonesia using GBD 2019 data also classified cardiovascular disease risk factors into the same three categories. These included low physical activity, risky dietary patterns, alcohol consumption, smoking, hypertension, high fasting glucose, high LDL cholesterol, obesity, and air pollution (10).

Risk factors contribute to the development and progression of IHD through complex biological mechanisms. These mechanisms include endothelial dysfunction, oxidative stress, chronic systemic inflammation, insulin resistance, and disturbances in metabolic and hemodynamic regulation (19)(20)(21)(22)(23). Collectively, these pathological changes trigger and accelerate atherosclerotic plaque formation and vascular remodeling, which in turn lead to arterial narrowing, reduced blood flow to the heart muscle, and increased vulnerability to plaque rupture and thrombosis (24)(25). The cumulative effect of these mechanisms disrupts coronary circulation and elevates the risk of IHD.

Over the past two decades, hypertension has been the leading risk factor for IHD-related DALYs in Indonesia, followed by risky dietary patterns. Hypertension is also a major contributor to the global burden of IHD, particularly in low and middle income countries (26). Findings from the GBD 2021 study on the burden of CVD in China similarly indicate that hypertension is the primary contributor to both mortality and DALYs due to CVD (27). Individuals with hypertension have a cardiovascular mortality risk that is twice as high as those without the condition (28).

The results of this study indicate that in both 2002 and 2021, metabolic risk factors had a significant impact on IHD-related DALYs in Indonesia. Metabolic risk factors such as obesity, high fasting glucose, and high LDL cholesterol are among the most significant contributors to the rise in age standardized death rate (ASDR) (26). Consistent with these findings, previous studies have reported similar trends. Between 1990 and 2021, the total IHD-related DALYs attributable to obesity doubled, increasing from 11.92 million to 23.91 million (29). IHD is recognized as the primary contributor to the global burden of cardiovascular disease due to obesity (30).

Other studies have shown that the combination of high fasting glucose and elevated LDL cholesterol can increase the risk of cardiovascular disease by accelerating atherosclerosis through inflammation, metabolic disturbances, and biological interactions (31). High blood sugar levels contributed to 1,910 DALYs

due to cardiovascular disease per 100,000 population in 2021 (32). An increase in ischemic heart disease burden due to high fasting glucose was noted from 1990 to 2021, with the steepest rises occurring in resource-constrained areas (18).

Previous research has also shown that high LDL cholesterol was the leading risk factor for the IHD burden from 2019 to 2021. In 2021, high LDL cholesterol accounted for 66.75 million healthy life years lost, representing approximately 38.40% of total IHD-related DALYs (33). LDL cholesterol has been identified as the primary risk factor for the development of atherosclerosis-related diseases such as IHD (34). Exposure to oxidized LDL cholesterol triggers an inflammatory response that contributes to vascular injury and plaque formation (35).

Alongside metabolic risks, behavioral risk factors significantly contribute to IHD-related DALYs. The results of this study indicate that tobacco use, low physical activity, and risky dietary patterns have a substantial impact on IHD-related DALYs in Indonesia. According to GBD 2021 data, the DALYs rate attributable to behavioral risk factors increased by 3.46%, from 1,692.57 to 1,751.06 per 100,000 population between 2002 and 2021(11). This suggests that the lifestyle of people in Indonesia is becoming increasingly unhealthy. risky dietary patterns characterized by low intake of whole grains and legumes and high sodium consumption contribute significantly to increased IHD-related DALYs, particularly in regions with low to moderate socio demographic index (SDI) levels (36).

Low physical activity is a major contributor to premature death, morbidity, and DALYs due to cardiovascular disease in most countries worldwide. Globally, IHD-related DALYs caused by low physical activity increased from 8.61 million in 1990 to 15.7 million in 2019 (6). A study conducted in Switzerland in 2017 found that the highest productivity loss due to smoking was associated with IHD (37). Tobacco accounts for 24 million DALYs, with ischemic heart disease among the primary conditions driving this burden in India (38).

Environmental factors such as non-optimal temperature and air pollution did not significantly affect IHD-related DALYs in Indonesia. This finding contrasts with previous research, which identified air pollution as a leading contributor to the global disease burden in 2021, accounting for approximately 8.0% (95% UI 6.7–9.4) of total DALYs. Across nearly all Socio-demographic Index levels, air pollution ranks within the top three risk factors and is also among the top five globally (39).

Extreme temperatures, whether hot or cold, significantly impact global population health (40). Low air temperatures have been associated with an increase in daily hospitalizations for heart disease in the general population (41). Consistent with these findings, a study conducted in Puducherry, a tropical region in India, between 2011 and 2020 showed no significant association between extreme temperatures and IHD mortality (42).

CONCLUSIONS AND SUGGESTIONS

Conclusion

Over the past two decades (2002–2021), the burden of IHD (DALYs lost) has increased by 10.5%. Throughout this period, North Maluku has consistently recorded the highest IHD-related DALYs among all provinces, while North Kalimantan has consistently reported the lowest. Among all risk factors, hypertension has consistently accounted for the highest burden in terms of IHD-related DALYs in Indonesia over the past 20 years. Tobacco use and a principal component encompassing six major risk factors (low physical activity, risky dietary patterns, obesity, high LDL cholesterol cholesterol, hypertension, and high fasting glucose) significantly influenced to the burden of IHD in both 2002 and 2021. In contrast, environmental factors such as non-optimal

temperature and air pollution did not show a significant influence.

Suggestion

There is a need to strengthen health programs with greater emphasis on controlling the seven risk factors that contribute to the burden of IHD, particularly those that are modifiable, such as low physical activity, risky dietary patterns, and tobacco use. In addition, regular health screenings are essential. These efforts are crucial to reducing the burden of IHD (DALYs lost) in Indonesia.

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AUTHOR CONTRIBUTIONS

This manuscript was a collaborative effort among all authors. AMS was responsible for data analysis and drafting the manuscript, with KDA and DI contributing through supervisory input and content refinement.

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