

META-ANALISIS: THE IMPACT OF SMOKING HABITS AND HYPERTENSION ON CORONARY HEART DISEASE IN PRODUCTIVE AGE GROUP

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Abstract

The global disease burden has shifted epidemiologically toward non-communicable diseases (NCDs), with coronary heart disease (CHD) as the leading cause of global mortality, contributing to 36% of deaths. This study aimed to identify the effect size and variability model of CHD determinants in the productive age group. A systematic review and meta-analysis approach was conducted between January and May 2025. Primary data were retrieved from Google Scholar, PubMed, and Scopus, restricted to studies published from 2019 to 2023. Out of 18,132 articles identified, 12 studies met the eligibility criteria. Data were analyzed using STATA 17.0. The systematic review protocol was prospectively registered in PROSPERO (Registration: CRD420250602556). The proportion of CHD in the productive age group was 5.3% (95% CI: 1.50–9.00). The meta-analysis of smoking habits showed a non-significant association with CHD (OR = 1.29; 95% CI = 0.54–1.69; $p = 0.397$), whereas hypertension was found to have a significant impact (OR = 1.95; 95% CI = 1.49–2.42; $p = 0.176$). No publication bias was detected. Hypertension significantly contributes to the incidence of CHD in the productive age group. CHD prevention should target this age group, especially in countries with high CHD prevalence. Interventions should include physical activity promotion, aggressive anti-smoking campaigns, nutritional education to reduce obesity, and early screening and management of diabetes and hypertension at the primary healthcare level.

Keywords: Meta-analysis, Systematic Review, Risk Factors, Coronary Heart Disease (CHD), Productive Age Group

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INTRODUCTION

Non-communicable diseases (NCDs) have become the leading cause of global mortality, accounting for 74% of all deaths worldwide, with 41 million deaths annually, over 15 million of which occur in the productive age range (30–69 years), particularly in low- and middle-income countries. The burden of these diseases, measured in Disability Adjusted Life Years (DALYs), demonstrates a significant epidemiological transition toward NCDs, including a dramatic increase in ischemic heart disease (113.9% from 1990–2017)(1).

In 2020, Coronary Heart Disease (CHD) was estimated to be the leading cause of mortality globally, with a rate of 36%(2). Based on Indonesia's Basic Health Research (Riskesdas) from 2013 to 2018, the prevalence of CHD reached 1.5%(3). Although the 2023 Indonesian Health Survey (SKI) reported a decrease in CHD prevalence in Indonesia (0.85%), the productive age group (15–64 years), which dominated the population (69.13% in 2023), showed an increasing prevalence(4). CHD in the productive age group causes significant consequences, including premature death, decreased productivity, economic burden, disability, and psychological disorders. It is estimated that 1.45% of the working-age population in Indonesia suffers from CHD, potentially leading to the loss of millions of years of life, Quality-Adjusted Life Year (QALY), and Disability-Adjusted Life Years (DALY)(5).

Modernization and lifestyle changes play a significant role in the rise of CHD among the productive age group. Risky behaviors such as fast food consumption, smoking, stress,

obesity, diabetes, and high blood pressure pose a global threat. Epidemiological studies classify CHD risk factors into modifiable and non-modifiable types. The Framingham Study categorizes cardiovascular disease risk factors into atherogenic, behavioral, environmental, and minor factors(6). Other epidemiological studies group CHD risk factors similarly into two categories consisting of modifiable and non-modifiable(7)(8). A large body of scientific evidence identifies modifiable risk factors as the primary drivers of the CHD epidemic, with smoking habits and hypertension being the most prominent.

The transition to a modern, sedentary lifestyle has created a "perfect storm" for cardiovascular health, particularly among working-age adults. In Southeast Asian contexts such as Indonesia, this trend is reflected in recent clinical data. Research conducted at RSUD Dr. R. Koesma (2025) indicates that hypertension (51%) remains the leading "silent killer" among cardiac outpatients(9).

Data from the Framingham Offspring cohort (mean age 42) showed that quitting smoking within the first five years can reduce cardiovascular risk by up to 39% compared to active smokers; however, the risk remains higher than among never-smokers. Biologically, smoking triggers endothelial dysfunction, increased oxidative stress, and inflammation, cumulatively contributing to coronary atherosclerosis. Smoking is also significantly associated with increased CHD risk. A study found that smokers are 1.61 to 5.85 times more likely to develop CHD than non-smokers(10).

Hypertension significantly influences CHD risk and is a dominant risk factor. Individuals with lower socioeconomic status are more likely to develop CHD due to limited access to health information and healthy lifestyle choices. A study found that obese individuals are 1.45 times more likely to develop CHD than non-obese individuals. Diabetes mellitus is also a significant risk factor, with an odds ratio of 8.43. Data show that individuals with a history of hypertension are 10.09 times more likely to develop CHD compared to those without hypertension (11).

A systematic review is conducted to identify the consistency of research findings, including conflicting results, research gaps, unanswered questions, and the need for further studies. The meta-analysis phase is then carried out to provide the strongest scientific evidence on the effects of interventions or exposures among all included primary studies, enhancing internal validity, broadening external validity, increasing statistical power, reducing random error, and improving estimate precision. Despite advancements in CHD prevention strategies, CHD remains a leading cause of premature death globally(12). Given the variation in primary study results, systematic review and meta-analysis are necessary to identify consistency, address research gaps, and provide robust scientific evidence on the effects of interventions or exposures. Hence, this study aims to conduct a meta-analysis on the proportion and determinants of CHD in the productive age group.

METHODS

This research is an analytical observational study utilizing a systematic review with meta-analysis as the statistical approach. Primary studies were screened from 2019 to 2023, with data collection conducted from January to May 2025. The study population consisted of individuals in the productive age group (15–64 years), based on the Indonesian Ministry of

Health Regulation (2017). The researchers employed the PICOTS framework (Population, Intervention, Comparison, Outcome, Time, and Study Design) to focus the research objectives.

Databases used for the study included Scopus, PubMed, and Google Scholar. Articles were searched using keywords and Boolean operators (AND, OR, NOT, AND NOT). The search terms were constructed using Medical Subject Headings (MeSH), namely: (((((Determinant) OR (Risk Factor) OR (Causative Factor) OR (Smoking Habit) OR (Hypertension)) AND ((Coronary Heart Disease))) AND ((Productive Age Group) OR (Working Age Population))). During the data review phase, identified journal articles were initially screened for duplicates using Mendeley. After removing duplicates, titles were reviewed for relevance. Articles were then assessed by abstract screening and proceeded to data reliability assessment. Once the relevant articles were obtained, critical appraisal of study quality was conducted. Selected studies included in the meta-analysis were evaluated using the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist.

This study used full-text primary data-based articles, focusing on Coronary Heart Disease (CHD) and its determinants, as inclusion criteria. The literature search was conducted using Publish or Perish software, while the systematic selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. All collected data were then analyzed using STATA 17.0.

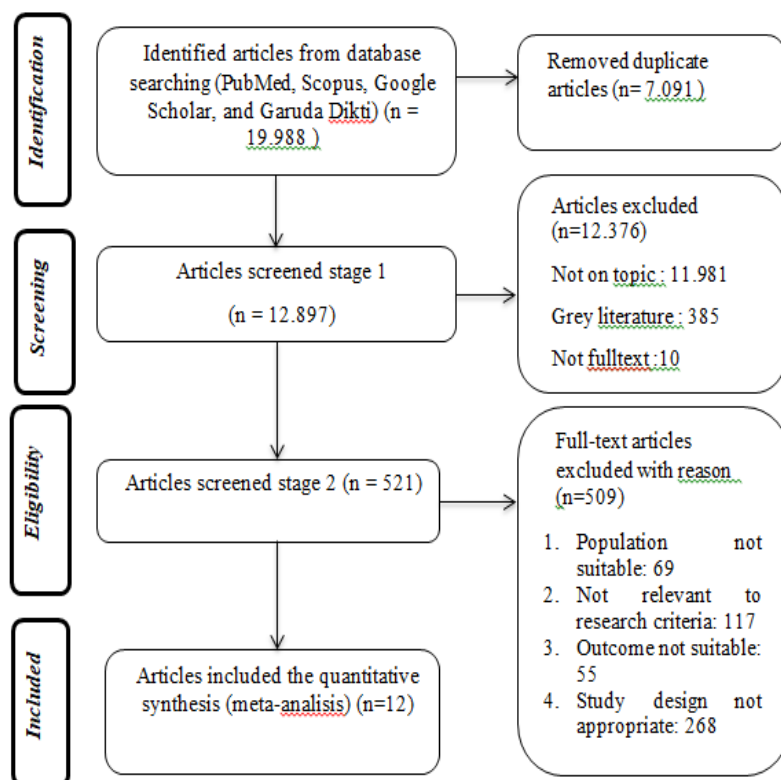


Figure 1 PRISMA Flowchart

RESULTS

Research Area Overview

Twelve primary studies investigating the proportion and determinants of coronary heart disease (CHD) were identified, originating from Asia and Africa. Asia contributed the most

studies, with research conducted in Indonesia, India, Japan, Lebanon, Palestine, and China. One study was from Ethiopia, representing Africa. The analysis explored the magnitude of CHD and its associated risk factors in the productive age group population. Descriptions of the included primary studies are presented in Table 1.

Table 1. Description of primary studies included in the meta-analysis

No.	Authors/Year	Study Design	Location	Sample
1.	Chacko, <i>et al</i> (2020)(13)	Case Control	India	340
2.	Shahwan, <i>et al</i> (2019) (14)	Cross-Sectional	Palestine	2240
3.	Ghaddar, <i>et al</i> (2022)(15)	Case Control	Lebanon	1500
4.	Qin, <i>et al</i> (2021)(16)	Cross-Sectional	China	1355
5.	Kurpp, <i>et al</i> (2021) (17)	Cross-Sectional	India	734
6.	Yamada, <i>et al</i> (2023)(18)	Cross-Sectional	Japan	10,572
7.	Li C, <i>et al</i> (2020)(19)	Case Control	China	781
8.	Gebremedhin, <i>et al</i> (2021)(20)	Case Control	Ethiopia	557
9.	Sudikno, <i>et al</i> (2023)(21)	Case Control	Indonesia	592
10.	Wang Y, <i>et al</i> (2020)(22)	Cohort	China	39.259
11.	Jayaram, <i>et al</i> (2019)(23)	Cohort	India	258
12.	Jiao He, <i>et al</i> (2023)(24)	Cross-sectional	China	102.576

Proportion Coronary Heart Disease (CHD)

In this study, the proportion of Coronary Heart Disease (CHD) was derived from four primary studies with a cross-sectional design. The distribution of CHD proportions from these primary studies.

Based on five cross-sectional primary studies, the highest proportion of Coronary Heart Disease (CHD) was reported in the study by Shahwan (2019) conducted in Palestine, with a prevalence of 8.3%. Conversely, the lowest CHD prevalence was observed in the study by Yamada et al. (2023) among male workers in Japan, at 1.4%.

Table 2. Proportion Analysis

Study identifier (Year)	Proportion	[95% Conf. Interval]		% Weight
Shahwan, <i>et al</i> (2019)	8,3	7,2	9,5	19.41
Kurpp, <i>et al</i> (2021)	6,4	4,7	8,7	14.44
Qin, <i>et al</i> (2021)	5,1	4,0	6,4	19.16
Jiao He, <i>et al</i> (2023)	2,6	2,5	2,7	23.57
Yamada, <i>et al</i> (2023)	1,4	1,2	1,7	23.41
Overall, DL	4,4	3,3	5,6	100.000

From the analysis of four primary studies using a cross-sectional approach, the average proportion of coronary heart disease (CHD) was found to be 5.3% (95% CI: 1.5–9.0).

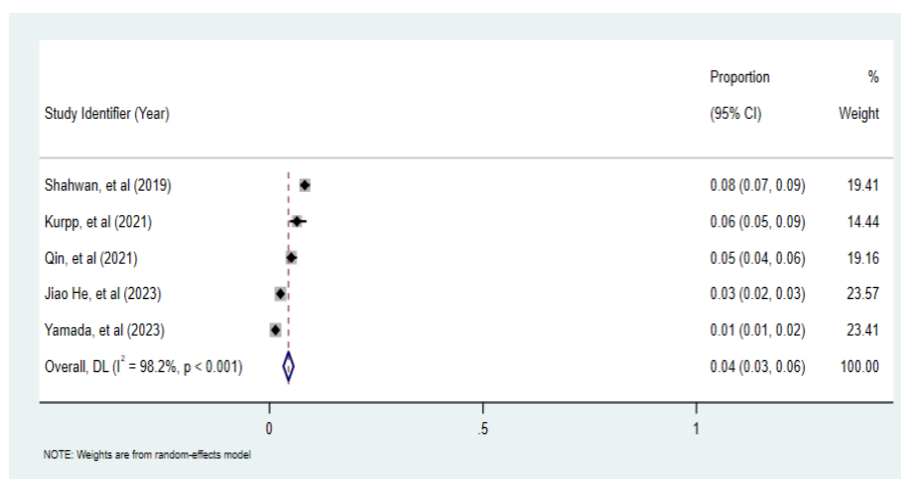


Figure 2. Forest Plot of Coronary Heart Disease (CHD) Proportion

The analysis of the primary studies with a cross-sectional design revealed an I^2 value of 98.4% with $p < 0.001$. This indicates that the prevalence of Coronary Heart Disease (CHD) reported in the primary studies varied considerably, demonstrating substantial heterogeneity. This conclusion is supported by heterogeneity indicators, including an I^2 value greater than 25%, a Cochran's Q p-value less than 0.1, and a forest plot showing that some studies had confidence intervals that did not overlap with those of other studies.

This report details the proportion of key determinants for Coronary Heart Disease (CHD), specifically focusing on smoking habits and hypertension.

Table 3. Proportion Determinant Analysis

Variables	Study Identifier (Year)	Proportion	(95% CI)		% Weight
Smoking Habits	Jayaram, <i>et al</i> (2019)	31,4	26,0	37,3	19,97
	Chacko, <i>et al</i> (2020)	42,6	37,5	48,0	19,98
	Wang Y, <i>et al</i> (2020)	17,8	17,5	18,2	20,03
	Sudikno, <i>et al</i> (2021)	31,3	27,6	35,1	20,00
	Yamada, <i>et al</i> (2023)	96,1	95,7	96,4	20,03
	Overall, DL	43,9	-4,0	91,8	100.000
Hypertension	Shahwan, <i>et al</i> (2019)	28,4	26,6	30,3	14,37
	Chacko, <i>et al</i> (2020)	40,9	35,8	46,2	14,07
	Gebremedhin, <i>et al</i> (2021)	43,4	39,4	47,6	14,20
	Kurpp, <i>et al</i> (2021)	23,9	20,7	27,4	14,27
	Qin, <i>et al</i> (2021)	44,7	42,1	47,4	14,33
	Ghaddar, <i>et al</i> (2022)	73,0	70,7	75,2	14,35
	Yamada, <i>et al</i> (2023)	30,4	29,6	31,3	14,41
	Overall, DL	40,7	28,1	53,3	100.000

Based on five studies, the highest proportion of smoking habits was again identified in Yamada's (2023) research in Japan, at 96.1%. Conversely, the lowest proportion was reported by Jayaram et al. (2020) among male workers in India, at 31.4%. An analysis of these five primary studies indicated an overall proportion of smoking habits contributing to CHD of 43.9% (95% CI: 4.0-91.8; p-value < 0.001).

From seven studies, the highest proportion for hypertension was found in Chacko et al.'s (2020) research in India, at 31.9%. The lowest proportion was observed in Yamada et al.'s (2021) study in Japan, at 17.8%. An analysis of these seven studies revealed an overall proportion of hypertension incidence at 40.7% (95% CI: 28.1-53.3).

Smoking Habits

Five articles consisting of 1 cohort study, 2 case control studies, and 2 cross sectional studies were included in the meta-analysis on the relationship between smoking habits and CHD in the productive age group. These studies originated from India, Indonesia, China and Japan. The meta-analysis revealed an I^2 value of 0.0%, indicating no heterogeneity in effect estimates across primary studies. Hence, the fixed-effect model was used. Subgroup analysis showed that smoking increased the risk of CHD by 1.29 times compared to non-smokers, although this was not statistically significant (OR = 1.29; 95% CI = 0.98–1.61).

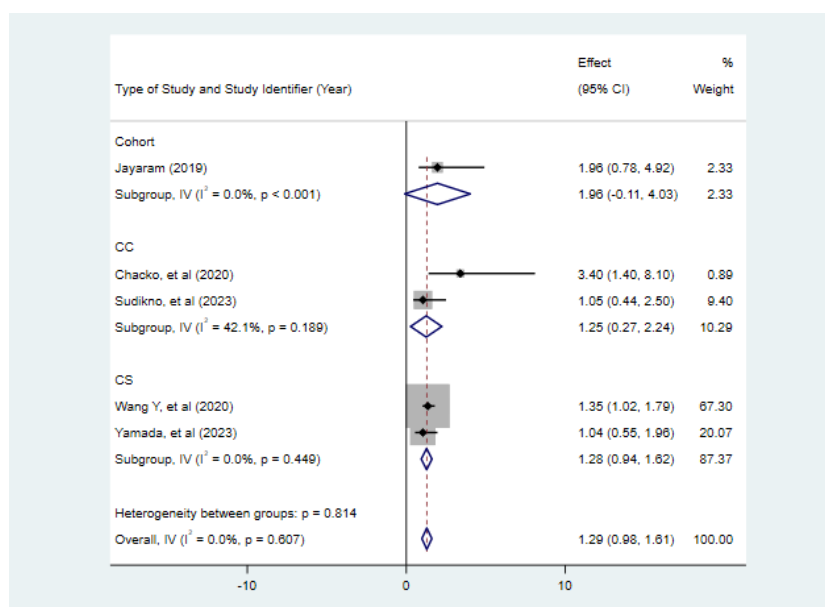


Figure 3. Forest Plot of Smoking Habits on Coronary Heart Disease (CHD)

The funnel plot showed that the distribution of effect estimates from cross-sectional and case-control studies aligned vertically, suggesting no publication bias.

Hypertension

Eight articles consisting of five cross-sectional studies and three case-control studies were included in the meta-analysis examining the relationship between hypertension and CHD in the productive age group. These studies originated from Palestine, India, Japan, Indonesia, China, Ethiopia, and Lebanon. The meta-analysis showed an I^2 value of 25.5%, indicating moderate heterogeneity in effect estimates across studies. Thus, a random-effect model was applied. Subgroup analysis revealed that individuals with hypertension had a 1.95 times higher risk of CHD compared to those without hypertension, and this was statistically significant (OR = 1.95; 95% CI = 1.49–2.42).

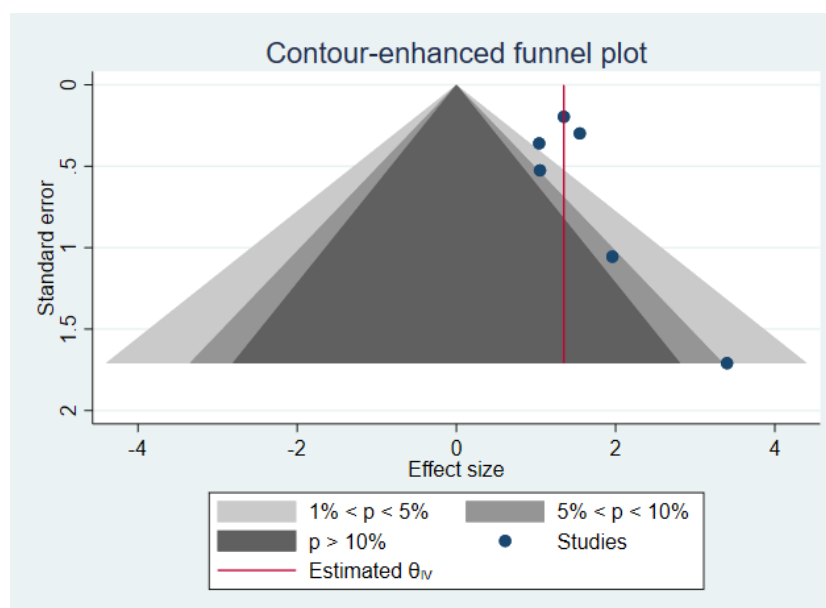


Figure 4. Funnel Countour Plot of Hypertension Against Coronary Heart Disease (CHD)

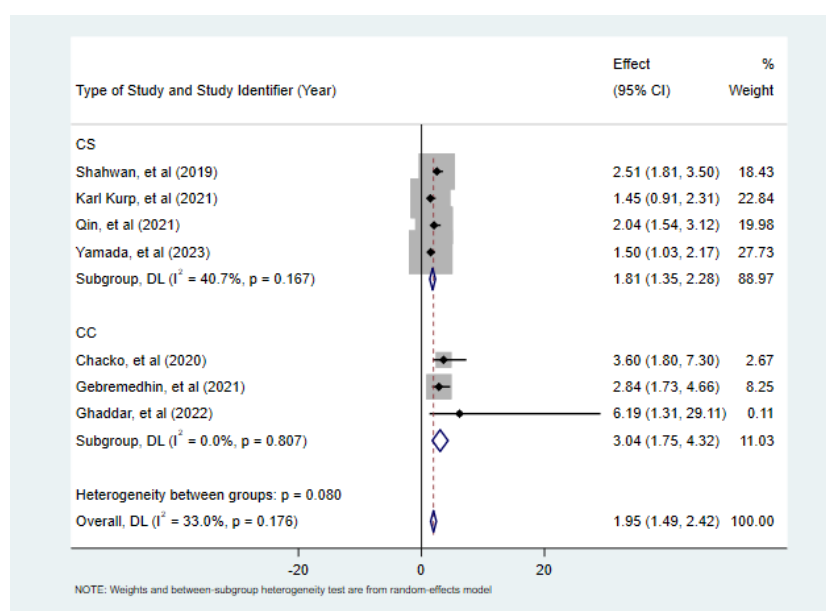


Figure 5. Forest Plot of Hypertension Against Coronary Heart Disease (CHD)

The funnel plot for hypertension also showed that the distribution of effect estimates from both study types aligned vertically, indicating no publication bias.

DISCUSSION

The results from five studies reporting the proportion of coronary heart disease (CHD) in various populations demonstrated substantial variation, as reflected in a high I^2 value of 98.4%. Thus, a random-effects model was chosen due to the significant heterogeneity between studies. The combined estimate from these four primary studies revealed a CHD proportion of 5.3%, although the overall effect was not statistically significant.

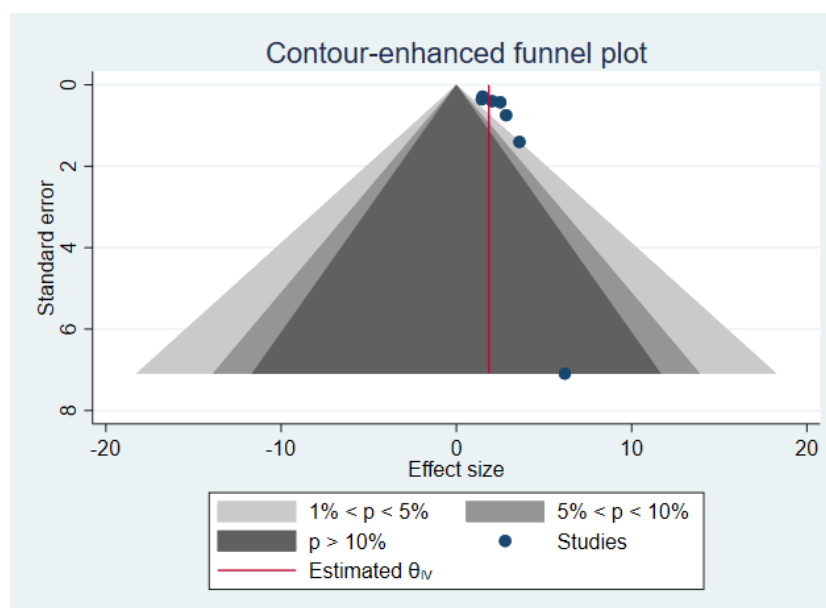


Figure 6. Funnel Contour Plot of Hypertension Against Coronary Heart Disease (CHD)

Among the five identified cross-sectional studies, there was a wide range in CHD prevalence. The highest proportion was reported in Palestine by Shahwan et al. (2019) at 8.3%, while the lowest was observed in Japan by Yamada et al. (2023) at 1.4%. These differences may stem from complex factors including epidemiological and demographic transitions, rapid urbanization and lifestyle changes, increased risk factors, and health system disparities.

The global burden of cardiovascular disease (CVD) in adolescents and young adults has increased significantly. From 1990 to 2019, the absolute incidence of CVD in this age group rose by 45.5%. Deaths and DALYs (Disability-Adjusted Life Years) linked to CVD rose by 21.6% and 18%, respectively. In 2019 alone, there were 5.7 million new CVD cases, 45.4 million related DALYs, and 761,000 deaths globally in youth and young adults(25). These increases are most evident in countries with low and middle Social Development Index scores.

This study is consistent with global meta-analyses, such as the Global Burden of Disease Study 2019, which confirmed CHD as the leading global cause of death with 9.1 million deaths in 2019(26). Although age-standardized CHD mortality has declined in many regions, the total burden and case numbers among working-age adults continue to rise, particularly in low- and middle-income countries.

This study found that smoking increased the risk of CHD by 1.11 times, though this association was not statistically significant (OR = 1.11; 95% CI: 0.54–1.69). Case-control studies by Chacko and Sudikno, and a cross-sectional study by Yamada, consistently demonstrated a positive association between smoking and CHD. However, when pooled in this meta-analysis, statistical significance was not reached, likely due to the limited number of included studies and potential heterogeneity.

This lack of statistical significance is likely attributable to limited statistical power resulting from the small number of included studies. This meta-analysis incorporated only five articles regarding the smoking variable, which technically constrained the cumulative sample size's capacity to detect a small yet consistent effect. Furthermore, the wide confidence interval (0.54–1.69) reflects low precision, a common occurrence in meta-analyses with a limited

number of studies or high variability among primary research. Nevertheless, these statistically non-significant findings do not negate the clinical significance of smoking behavior in relation to cardiovascular health.

Epidemiological evidence consistently shows that smoking increases the risk of myocardial infarction (MI) and fatal coronary events. Even low-tar cigarettes and smokeless tobacco raise cardiovascular risk. Secondhand smoke exposure also increases CHD risk by approximately 30%, compared to an 80% increase in active smokers(27). The U.S. CDC estimates that smokers have a 2 to 4 times higher risk of developing CHD than non-smokers(28). A meta-analysis of millions of participants confirmed that smoking causes up to one-third of all CHD deaths(29).

The discrepancy between the results of this meta-analysis and larger global studies emphasizes that within the analyzed productive age population, the effects of smoking may be masked by other more dominant risk factors, such as hypertension, or may require a longer exposure period to manifest significantly in a smaller statistical analysis. Consequently, anti-smoking intervention campaigns remain a crucial priority in the prevention of CHD within the productive age group.

This study demonstrated that individuals with hypertension were 1.95 times more likely to develop CHD, a finding that reached statistical significance (OR = 1.95; 95% CI: 1.49–2.42). Most of the included studies consistently supported a strong and significant link between hypertension and CHD. This robust association aligns with global epidemiological data, which identifies hypertension as the leading modifiable risk factor for cardiovascular diseases, particularly in the productive age group.

Hypertension is the most common risk factor for CHD and a leading cause of heart attacks and strokes globally. Persistent high pressure damages arterial walls, triggers inflammation, and accelerates atherosclerosis. It also increases cardiac workload, potentially leading to left ventricular hypertrophy and heart failure(30). In summary, hypertension contributes significantly to CHD by damaging vascular endothelium, promoting inflammation, remodeling arteries, increasing oxidative stress, altering lipid profiles, and overloading the heart. These mechanisms drive the onset, progression, and complications of atherosclerosis, which eventually manifests as CHD.

This supports WHO's estimate that 1.28 billion adults aged 30–79 worldwide have hypertension, with nearly half unaware of their condition(31). The subgroup analysis in this study showed a strong clinical association between hypertension and CHD. Despite possible heterogeneity, the large effect size emphasizes the importance of this relationship.

Furthermore, the substantial effect size observed in this meta-analysis (OR = 1.95) underscores the urgency of early blood pressure control. This is further corroborated by Zhou et al. (2021)(32), who demonstrated that rigorous hypertension management within the productive age group directly reduces the incidence of myocardial infarction. Given the WHO estimate that nearly half of the 1.28 billion adults with hypertension are unaware of their condition, these findings highlight the critical necessity of strengthening primary healthcare services for early detection to achieve the Sustainable Development Goals (SDGs) regarding the reduction of premature mortality from non-communicable diseases.

The World Health Organization (WHO) highlights CHD as a major component of non-communicable diseases responsible for most premature deaths. Its global action plan targets a 25% reduction in premature mortality from NCDs by 2025 (compared to 2010), and a one-third reduction by 2030 as part of the Sustainable Development Goals (SDGs)(31). WHO recommends a comprehensive strategy involving tobacco taxation, dietary regulation, early detection, chronic disease management in primary care, and healthy lifestyle promotion. The high CHD prevalence among working-age adults, as seen in this study, poses serious challenges to achieving those goals.

CONCLUSION AND RECOMMENDATION

A meta-analysis of nine studies across seven countries Indonesia, India, Japan, Lebanon, Palestine, China, and Ethiopia revealed that the pooled prevalence of Coronary Heart Disease (CHD) among the productive age group is 5.3% (95% CI: 1.50–9.00). Significant geographical variation was observed, with high heterogeneity ($I^2 = 98.4\%$), ranging from the lowest prevalence in Japan (1.4%) to the highest in Palestine (8.3%).

Hypertension was statistically identified as the most significant risk factor. Individuals with hypertension face a 1.95 times higher risk of developing CHD compared to those with normal blood pressure (OR = 1.95; 95% CI: 1.49–2.42; $p < 0.05$). Regarding tobacco use, the analysis indicated that smokers had a 1.29 times higher likelihood of developing CHD compared to non-smokers. However, this association did not reach statistical significance within this specific meta-analysis (OR = 1.29; 95% CI: 0.94–1.62; $p = 0.397$). This lack of significance is likely attributable to the limited number of primary studies included in the synthesis.

These findings underscore the urgent need for aggressive interventions targeting the productive age group. Key strategies should include strengthening early hypertension screening in primary healthcare settings, intensifying anti-smoking campaigns, and promoting healthy lifestyle education. Such measures are essential to mitigate the economic and social burdens resulting from premature mortality and diminished workforce productivity

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