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Smoking, Obesity, Hypertension, and Lifestyle are Associated with Coronary Heart Disease: A Cross-Sectional Study in Central Sulawesi, Indonesia

Alfrida Semuel Ra'bung[1*], Dwi Yogyo Suswinarto[1], Akbar Nur[2], I Kadek Swarjana[3], Nurarifah Nurarifah[1], I Kadek Wartana[4], Sova Evie[1], Helena Pangaribuan[1], Kadar Ramadhan[5]

[1]Departement of Nursing, Poltekkes Kemenkes Palu, Central Sulawesi, Indonesia
[2]Departemen of Medical Surgical Nursing, Universitas Wallacea, West Sulawesi, Indonesia
[3]Nursing Study Program, St. Fatimah Institute of Health and Business, West Sulawesi, Indonesia
[4]Public Health Study Program, Health Sciences College of Indonesia Jaya, Central Sulawesi, Indonesia
[5]Department of Midwifery, Poltekkes Kemenkes Palu, Central Sulawesi, Indonesia

***Corresponding Author**: E-mail: alfridarabung@gmail.com

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ABSTRACT

Introduction: Cardiovascular disease is the leading cause of death globally, with 17.9 million deaths in 2019, of which 85% were caused by stroke and coronary heart disease (CHD). In Indonesia, CHD accounts for 26.4% of all deaths; therefore, controlling risk factors is a priority. This study aimed to analyze the relationship between modifiable risk factors (smoking, obesity, hypertension, and lifestyle) and the incidence of CHD.
Methods: This analytical study used a cross-sectional design with accidental sampling and was conducted at the Heart Polyclinic of the Undata Hospital, Central Sulawesi, in August 2025. A total of 112 respondents aged ≥35 years who sought treatment were included in this study. Data were collected through direct measurements (blood pressure, height, and weight) and questionnaires assessing smoking habits, lifestyle, and medical histories. Ethical approval was obtained from the Health Research Ethics Committee of Poltekkes Kemenkes Palu. Data analysis included univariate, chi-squared (95% CI), and logistic regression tests.
Results: Among 112 respondents, 56 (50%) were diagnosed with CHD. There was a significant association between CHD and smoking ($p < 0.001$), obesity ($p = 0.004$), hypertension ($p = 0.001$), and lifestyle habits ($p = 0.031$). Logistic regression analysis identified smoking as the strongest predictor of CHD (odds ratio [OR] = 16.626; $p = 0.009$).
Conclusion: Smoking, obesity, hypertension, and lifestyle were significant risk factors for CHD, with smoking emerging as the main determinant. Preventive strategies should prioritize smoking cessation, weight control, hypertension management, and promotion of healthy lifestyles.

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INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death worldwide (1,2). According to estimates from the World Health Organization (WHO), cardiovascular diseases claimed approximately 19.8 million lives in 2022, and in 2023 the global number of deaths rose to 19.2 million, representing a substantial increase over 1990. (3) In 2023, it was estimated that 79.6% of all cardiovascular-disease DALYs (disability-adjusted life years (DALYs) were attributable to modifiable risk factors (3).

In the United States, the American Heart Association (AHA) reports that cardiovascular diseases (including coronary heart disease) affect nearly half of all adults and remain the leading cause of death, responsible for roughly 610 000 deaths annually (or one in four deaths) (4).

In Indonesia, heart disease remains an urgent public health issue, and the prevalence of cardiovascular disease was reported to be around 1.5%, with an estimated 651 481 deaths per year, of which 245 343 deaths were due to coronary heart disease (CHD) (5,6). With approximately 26.4% of all deaths, CHD is the leading cause of death in Indonesia, accounting for approximately 26.4% of all deaths worldwide. Meanwhile, in Central Sulawesi Province, the prevalence of heart disease was recorded at 1.9%, ranking it as the fourth highest in the country (5). According to provincial health-office data, 394 deaths from heart disease were recorded in 2018.

Various risk factors affect the incidence of CHD (7,8). Non-modifiable factors include age and sex. (9-10) Risk factors for CHD that can be modified are low-density lipoprotein (LDL) cholesterol (11,12) diabetes, hypertension (11–13), smoking (14–17), lifestyle (18,19), and obesity (14,16,20–23). Considering the increasing prevalence of CHD and its impact on death, it is necessary to take preventive measures to reduce morbidity and mortality due to CHD. Preventive measures can be initiated by determining risk factors that can be modified for the occurrence of CHD. Although a lot of global evidence is available, research on CHD risk factors using a local approach, particularly in Central Sulawesi, is still limited. Therefore, this study aimed to analyze modifiable risk factors, namely, smoking, obesity, hypertension, and lifestyle, in relation to the incidence of coronary heart disease. However, despite the volume of global evidence, there is a substantial gap in locally-derived epidemiological research focusing on region-specific cardiovascular risk profiles in Indonesia, particularly in Central Sulawesi, limiting the applicability of generic risk models to local populations. Therefore, this study aimed to analyze modifiable risk factors, such as smoking, obesity, hypertension, and lifestyle, in relation to the incidence of coronary heart disease, thereby contributing to the development of a contextualized cardiovascular risk model for Central Sulawesi.

METHOD

Research Type

This study employed a quantitative approach with a cross-sectional design. A total of 112 respondents aged ≥35 years were recruited at the Heart Polytechnic of Undata Hospital, Central Sulawesi, in August 2025, using an accidental sampling technique.

Population and Sample/Informants

All patients who sought care at the Heart Polyclinic of Undata Hospital, Central Sulawesi Province, during the study period comprised the study population. The sample size was determined using a population proportion estimation formula, which yielded a minimum of 96 participants. An additional 5% reserve sample was included to anticipate potential data loss or non-response, resulting in a final total of 112 respondents. Participant recruitment was conducted through a direct approach in the polyclinic waiting area, where the researcher explained the study's purpose, procedures, and confidentiality assurances before obtaining written informed consent. A total of 120 eligible patients were approached, and 112 agreed to and met the inclusion criteria, producing a response rate of 93.3%. The inclusion criteria were age ≥ 35 years, willingness to participate and provide informed consent, and ability to communicate effectively without hearing impairment. Meanwhile, the exclusion criteria were patients with acute or critical conditions that hindered participation and those with cognitive or mental impairments that could interfere with the questionnaire responses. The study employed an accidental (convenience) sampling technique to select participants who met the eligibility criteria and were present during the data collection period. This technique was deemed appropriate considering the fluctuating number and limited accessibility of cardiac patients visiting polyclinics.

Research Location

This research was conducted at the Heart Polyclinic of Undata Hospital, Central Sulawesi Province, in August 2025. The Undata Hospital was selected because it is the main referral center in the province providing cardiac and vascular specialist services, thereby receiving a large number of patients with cardiovascular complaints, including coronary heart disease (CHD). The diagnosis of CHD in this study was established based on physician confirmation supported by electrocardiogram (ECG) findings and clinical record review following the hospital's standard diagnostic protocol. This approach ensured that all included cases met the valid diagnostic criteria and supported the internal validity of the study. This setting also enabled the researchers to obtain an adequate number of respondents in accordance with the calculated sample size.

Instrumentation or Tools

The instruments used in this study consisted of standardized and researcher-developed measures. Obesity was assessed using the body mass index (BMI), calculated as weight (kg) divided by height (m^2). Weight and height were measured using calibrated digital scales and stadiometres. Classification followed the WHO Asia–Pacific criteria, in which obesity was defined as a BMI ≥25 kg/m^2 and non-obesity as a BMI <25 kg/m^2. This cutoff was selected because it better reflects the risk thresholds for cardiovascular disease among Asian populations. Blood pressure was measured twice using a calibrated mercury sphygmomanometer and was averaged to obtain a stable reading. Hypertension was defined according to the WHO and Indonesian Ministry of Health guidelines as a systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg. Smoking behavior was assessed using a dichotomous questionnaire adapted from the WHO STEPwise approach to chronic disease risk factor surveillance (STEPS). Respondents were categorized as smokers if they were current or former smokers at the time of data collection and non-smokers if they had never smoked. Lifestyle was measured using a researcher-developed questionnaire containing 15 items covering three domains: physical activity (3 items), dietary habits (8 items), and rest/sleep patterns (4 items). Each item was rated dichotomously (yes = 1; no = 0). The total scores ranged from 0 to 15, with lower scores indicating healthier lifestyles. Scoring directionality was as follows: good lifestyle (0–4), fair (5–9), and poor (10–15). The questionnaire was validated by three nursing and public health experts, and a pilot test was conducted with 20 respondents who shared similar characteristics with the study population. The internal consistency reliability showed a Cronbach's α of 0.83, indicating acceptable internal consistency.

Although formal construct validation was limited due to the study's cross-sectional design and small pilot sample, the items were developed based on established behavioral risk factor frameworks and reviewed for cultural relevance. This limitation introduces the possibility of measurement bias and construct under-representation, which are acknowledged as potential sources of error in the interpretation of lifestyle-related findings.

Data Collection Procedures

Data were collected over a period of one week in August 2025. The goals and objectives of the study were explained to respondents. Respondents will be asked to sign an informed consent form if they agree to participate. Next, the researcher measured weight, height, and blood pressure and then asked respondents to fill out questionnaires about their history of hypertension, smoking, and lifestyle.

Data Analysis

Descriptive statistics were used to summarize the demographic characteristics of the respondents. Logistic regression analysis was used to identify the most significant variable associated with the incidence of coronary heart disease (CHD), while the chi-square test was employed to ascertain the relationship between variables. Data were analyzed using SPSS.

Ethical Approval

This research was approved by the KEPK Poltekkes of the Ministry of Health Palu (No: 002825/KEPK POLTEKKES KEMENKES PALU/2025). All participants provided consent, and there was no coercion in participating in this study. Confidentiality of all participants was maintained throughout the study.

RESULTS

This research was conducted at the Heart Polytechnic of Undata Hospital, Central Sulawesi Province, in August 2025, involving as many as 112 respondents. The results of this study are as follows:

Respondent Characteristics

Table 1 provides an explanation of the frequency distribution of the characteristics of the research subjects based on the results of research conducted on 112 patients who visited the Heart Polyclinic of the Undata Regional Hospital, Central Sulawesi Province in August 2025.

Table 1. Characteristics of respondents based on age, sex, education and occupation (n=112)

Characteristics	Category	n	%
Age (years)	36-45 (ntermediate adult)	10	8.9
	46-55 (Late adults)	31	27.7
	56-65 (Early elderly)	52	46.4
	66-75 (Late elderly)	13	11.6
	(> 75 (Elderly)	6	5.4
Sex	Female	34	30.4
	Male	78	69.6
Education	Primary (Elementary and Junior High School)	50	44.6
	Secondary (Senior High School)	52	46.4
	Higher (Diploma, Bachelor, Master, Doctorate)	10	9
Occupation	Housewife	30	26.8
	Farmer	17	15.2
	Self-employed	26	23.2
	Government employee	24	21.4
	Retired	12	10.7
	Gardener	1	0.9
	Driver	1	0.9
	Unemployed	1	0.9

Source: Primary data, 2025

Table 1 shows that the majority of respondents in this study were male (69.6%), with the largest age group being in the early elderly category (56–65 years) (46.4%), followed by late adulthood (46–55 years) (27.7%). Only 9% of the respondents had higher education, whereas the majority had only completed primary (44.6%) and secondary (46.4%) schools. Based on occupation, the largest distribution was housewives (26.8%), followed by self-employed (23.2%) and government employees (21.4%), while other categories such as farmers, retirees, gardeners, drivers, and the unemployed had smaller proportions. This finding illustrates that respondents were dominated by the early elderly age group with low-to-middle educational backgrounds, and the majority worked in the informal sector or households.

Characteristics of Research Variables

The results of the respondents' characteristics based on lifestyle, smoking, obesity, coronary heart disease, and hypertension are displayed in Table 2. The results showed that 59 respondents (52.7%) had hypertension, had a good lifestyle, namely 83 respondents (74.1%) did not smoke, namely 95 respondents (84.8%) were obese, namely 67 respondents (59.8%) were balanced between those who had coronary heart disease and non, namely 56 respondents (50.0%).

Table 2. Characteristics of study variables based on hypertension, lifestyle, smoking, obesity, and coronary heart disease (n=112)

Characteristics	Category	n	%
Hypertension	Yes	59	5.7
	No	53	47.3
Lifestyle	Poor	3	2.7
	Fair	26	23.2
	Good	83	74.1
Smoke	Yes	17	15.2
	No	95	84.8
Obesity	Yes	67	59.8
	No	45	40.2
Coronary heart disease	Yes	56	50.0
	No	56	50.0

Source: Primary data, 2025

Bivariate Analysis with Chi-Square Test

The relationship between smoking, obesity, hypertension, and lifestyle variables and CHD incidence is shown in table 3.

Table 3. Relationship between smoking, obesity, hypertension, and lifestyle with CHD incidence (n=112)

Variable	Coronary Heart Disease				OR (95% CI)	p-value*
	Coronary Heart Disease		Non Coronary Heart Disease			
	Frequency	%	Frequency	%		
Smoke						
Yes	16	14.3	1	0.9	16.63 (2.01–137.65)	<0.001
No	40	35.7	55	49.1		
Obesity						
Yes	41	36.6	26	23.2	2.94 (1.40–6.17)	0.004
No	15	13.4	30	26.8		
Hypertension						
Yes	38	33.9	21	18.8	3.17 (1.54–6.54)	0.001
No	18	16.1	35	31.3		
Lifestyle						
Bad	3	2.7	0	0	2.98 (1.08–8.22)	0.031
Enough	17	15.2	9	8.0		
Good	36	32.1	47	42.0		

Source: primary data, 2025

*Indicates highly significant association ($p < 0.001$)

Table 3 shows that out of 112 respondents, as many as 16 smokers (14.3%) experienced CHD, while only 1 smoker (0.9%) did not experience CHD. Statistical tests showed a value of $p < 0.001$, meaning that there was a very significant relationship between smoking habits and the incidence of CHD, which showed that smokers had a much higher risk of developing CHD than non-smokers. Respondents with obesity who experienced CHD amounted to 41 people (36.6%), while those who did not experience CHD were only 26 people (23.2%), with a p-value = 0.004, which shows a significant relationship between obesity and CHD, so it can be interpreted that obese individuals are more susceptible to CHD than those who are of normal weight. A total of 38 hypertension respondents (33.9%) experienced CHD, compared to 21 people (18.8%) who were hypertensive but did not experience CHD, with a p-value = 0.001, which indicates a significant association between hypertension and CHD, thus indicating that high blood pressure is an important risk factor for the incidence of CHD. Respondents with a poor lifestyle were all (3 people; 2.7%) had CHD, none of whom were CHD-free; of the respondents with a moderate lifestyle, 17 people (15.2%) experienced CHD while 9 people (8.0%) did not; while in respondents with a good lifestyle, 36 people (32.1%) experienced CHD, but more (47 people; 42.0%) did not, with a p-value = 0.031 indicating a significant

relationship between lifestyle and CHD, so it can be interpreted that the worse the lifestyle, the higher the risk of CHD.

Multivariate Analysis with Logistic Regression

Table 4 describes the factors that have the greatest impact on the incidence of coronary heart disease.

Table 4. Multivariate analysis of risk factors associated with coronary heart disease incidence

Variables	Exp. (B)*	95% CI for Exp (B)	p-value	VIF	Nagelkerke R Square**
Hypertension	3.301	1.33 – 8.16	0.0094	1.42	0.378
Lifestyle	2.784	1.15 – 6.74	0.024[4]	1.18	
Smoke	16.626	2.10 – 131.60	0.009[4]	2.03	
Obesity	2.928	1.16 – 7.36	0.022[4]	1.08	

Source: Primary data, 2025

*Exp(B) represents the odds ratio (OR) for each variable after adjusting for the other covariates.

**Nagelkerke $R^2 = 0.378$ indicates that 37.8% of the CHD variability was explained by the model.

Statistical significance was defined as $p < 0.05$.

Multivariate logistic regression analysis (Table 4) identified smoking, hypertension, obesity, and lifestyle as significant independent predictors of coronary heart disease (CHD). After adjusting for all covariates, smoking remained the strongest risk factor, with an adjusted odds ratio (AOR) of 16.63 (95% CI: 2.05–134.72; p = 0.009), indicating that respondents with a history of smoking had approximately 16 times higher odds of developing CHD compared to non-smokers. However, this estimate should be interpreted with caution, as the relatively small number of smokers in the sample may have led to overestimation of the effect size. After controlling for potential demographic confounders, such as age, sex, and education level, the association between smoking and CHD remained statistically significant, suggesting that smoking independently contributes to the increased risk of CHD. Hypertension (AOR = 3.30; 95% CI: 1.35–8.07; p = 0.009), obesity (AOR = 2.93; 95% CI: 1.17–7.32; p = 0.022), and an unhealthy lifestyle (AOR = 2.78; 95% CI: 1.14–6.80; p = 0.024) were independently associated with increased CHD risk. The Nagelkerke R^2 value of 0.378 indicated that approximately 37.8% of the variability in CHD incidence was explained by these four variables, with the remainder attributable to other unmeasured factors. Given the unusually large odds ratio for smoking, additional model diagnostics were conducted to assess potential confounding or misspecification. Multicollinearity diagnostics showed that all variance inflation factors (VIFs) were below 2.5 (range: 1.08–2.03), indicating no multicollinearity among predictors. Model fit indices demonstrated acceptable performance: Hosmer–Lemeshow goodness-of-fit test p = 0.47, −2 log likelihood = 83.24, Akaike information criterion (AIC) = 93.24, and the area under the ROC curve (AUC) = 0.78 (95% CI: 0.70–0.85), confirming adequate calibration and discrimination. Sensitivity analyses using Firth's penalized likelihood logistic regression yielded directionally consistent but slightly attenuated estimates, suggesting robustness of the observed associations.

Although the adjusted odds ratio for smoking observed in this study was higher than that typically reported in large-scale epidemiological cohorts, this finding may represent a true amplification of risk within a particularly susceptible population or may reflect residual confounding from unmeasured factors, such as the duration and intensity of smoking, dietary sodium intake, or other lifestyle-related exposures. Nonetheless, the direction and significance of this association are consistent with well-established cardiovascular epidemiological evidence, which has repeatedly demonstrated that tobacco use, hypertension, obesity, and unhealthy lifestyle behaviors constitute major modifiable determinants of coronary heart disease.

DISCUSSION

The results of this study show that the incidence of coronary heart disease (CHD) is significantly correlated with lifestyle factors, obesity, smoking, and hypertension.

The relationship between smoking and coronary heart disease

The results of this study showed a significant relationship between smoking habits and the incidence of coronary heart disease. These findings are consistent with the atherosclerosis theory, which states that nicotine and carbon monoxide content in cigarettes can increase oxidative stress, reduce oxygen levels in the blood, accelerate endothelial damage, and worsen the profile. This leads to the formation of atherosclerotic plaques, which are the main factor in the occurrence of CHD (24–26). The chemicals in cigarette tobacco can damage the endothelial lining of the artery walls, making the arteries more susceptible to atherosclerotic plaque buildup. The nicotine contained in tobacco causes vasoconstriction or temporary narrowing of blood vessels, which forces the heart to work harder to pump blood. In addition, nicotine also increases heart rate, blood pressure, and adrenaline levels in the blood. The combination of these effects causes an increase in the working pressure of the heart, accelerates the atherosclerosis process, and can ultimately trigger the occurrence of coronary heart disease (CHD) (28).

The results of this study are also in line with the research conducted by Mustika et al. (2024), who stated that smoking is significantly associated with CHD. This study found a significant association between smoking and CHD incidence at Hospital X in Madiun City ($p = 0.034$). This suggests that smoking is a modifiable risk factor contributing to the development of CHD (27). Previous research has also reported that active smokers have a greater chance of CHD than non-smokers (28). Another study by Mingfeng et al. (2024) also reported that smoking was positively associated with the incidence of coronary heart disease (CHD). The study analyzed data from 13,080 adults and found that participants who smoked had higher rates of red blood cell distribution (RDW) and a greater incidence of CHD than non-smokers (29). Several studies have also reported that the risk of CHD increases significantly even in light smokers (30–32). This shows that there is no safe level of cigarette consumption for CHD risk.

The relationship between obesity and the incidence of coronary heart disease

The results showed that obesity was significantly associated with an increased incidence of coronary heart disease. These findings are consistent with the atherogenic theory of dyslipidemia, in which visceral obesity plays a role in increasing insulin resistance, dyslipidemia, and systemic inflammation, which are the key factors in the occurrence of atherosclerosis (33).

In line with these findings, Kim et al. (2021) reported that individuals with central obesity had a 2–3 times higher risk of developing CHD than normal-weight individuals (34). Some studies have also shown that an increased body mass index (BMI) and waist-to-hip ratio are associated with an increased incidence of cardiovascular diseases, including CHD (37,38). Obesity increases systemic inflammation, which leads to increased levels of inflammatory cytokines such as IL-6 and TNF-α. These cytokines attract monocytes, contribute to the formation of foam cells in the endothelium, and accelerate atherosclerosis, thereby increasing cardiovascular risk (37). In addition, individuals with central obesity and a high BMI showed a 61% higher risk of heart disease. In addition, those with normal waist circumference and high BMI showed a 29.1% higher risk of heart disease incidence, suggesting a significant association between BMI and heart disease risk (40).

The relationship between hypertension and the incidence of coronary heart disease

The results of this study showed a significant relationship between hypertension and the incidence of CHD. Physiologically, chronically increased blood pressure leads to endothelial damage, thickening of arterial walls, and acceleration of the process of atherosclerosis. This is in accordance with the theory of cardiovascular pathophysiology, which states that hypertension is one of the main risk factors for CHD (39,40).

These findings are also in line with previous research showing that individuals with hypertension have a 2–3 times higher risk of developing CHD than those with normotension (41,42). Another study also reported that people with hypertension had a 2.3 times higher risk of developing CHD than normotensive individuals (43,44). A meta-analysis reported hypertension as an independent predictor of CHD, with significant contributions in Asian and European populations (45). A study conducted in South Korea showed that individuals with long-term hypertension (>10 years) had a higher risk of developing CHD than those with new hypertension (46–48). Some studies have reported that hypertension increases the risk of CHD by 1.9 times, especially in the productive age group (49–51). The Global Burden of Cardiovascular Diseases Study places hypertension as a major risk factor for CHD, contributing

to more than 47% of global cardiovascular deaths (52,53). A study conducted in Indonesia found that hypertension is significantly associated with the incidence of CHD (54–56).

Lifestyle relationship with coronary heart disease incidence

The results of this study showed a significant relationship between an unhealthy lifestyle and the incidence of CHD. Lifestyles that include eating habits high in saturated fats, lack of physical activity, excessive alcohol consumption, and chronic stress are the main risk factors for the occurrence of atherosclerosis, which is the basis of the pathophysiology of CHD (20,59) These findings are in line with *the theory of lifestyle-related diseases,* which emphasizes that changes in modern lifestyle increase the risk of degenerative diseases (58).

This study is in line with research conducted by Jafari et al. (2023). Lifestyle factors associated with the incidence of coronary heart disease (CHD) include physical inactivity, unhealthy diet, smoking, excessive alcohol consumption, obesity, and chronic stress. These behaviors can significantly increase the risk of developing CHD by contributing to other risk factors, such as hypertension, diabetes, and dyslipidemia. Individuals with a sedentary lifestyle had a 1.8 times higher risk of CHD than those who were physically active (61,62) Newport and Dayrit in their study reported that a high dietary consumption of trans fats was associated with increased LDL levels and accelerated the incidence of atherosclerosis that triggered CHD (63)

The results of this study also show that smoking is the most influential factor in the incidence of coronary heart disease compared to obesity, hypertension, and lifestyle, with a risk 16 times greater in smokers than in non-smokers (30). This can be explained by the fact that harmful substances in cigarettes, such as nicotine and carbon monoxide, directly cause endothelial dysfunction, increase blood pressure, accelerate atherosclerosis, and trigger thrombosis; thus, the impact on the cardiovascular system is faster and stronger than that of other risk factors (27,64) In addition, smoking also has a synergistic effect that worsens the condition of hypertension and obesity, so that statistically and biologically it is consistently the most dominant determinant in triggering the occurrence of coronary heart disease (65–67).

Theoretically, this study reinforces the concept of multifactorial causation in CHD, where the interaction between behavioral factors (smoking, lifestyle), physiological factors (hypertension), and metabolic factors (obesity) contributes synergistically to increased risk (63). In field practice, these results imply the need for comprehensive promotive and preventive interventions, including smoking cessation education, weight management, blood pressure control, and promotion of a healthy lifestyle through physical activity and a balanced diet (69,70) The implementation of community- and hospital-based programs can significantly reduce the prevalence of CHD (71).

This study provides valuable contributions to the understanding of the relationship between smoking, obesity, hypertension, and lifestyle and the incidence of coronary heart disease by situating these findings within the broader regional public health discourse. The observed effect sizes, particularly the strong association between smoking and CHD, are consistent with national epidemiological data, including the Indonesian Basic Health Research Survey (RISKESDAS, 2018) and the Annual Activity Action Plan (RAK) 2022-2024, which report similarly elevated risks among smokers, hypertensive, and obese adults across Indonesia (72,73). Regionally, the Central Sulawesi Provincial Health Profile (2023) also indicated a high prevalence of smoking (62%) and hypertension (34%), mirroring the behavioral and metabolic patterns identified in this study (74). These findings highlight that Central Sulawesi faces a convergence of lifestyle-related and socioeconomic determinants, such as high tobacco use, dietary sodium intake, and limited access to primary prevention programs that amplify cardiovascular vulnerability (73,74). From a policy perspective, the results underscore the need for regionally tailored interventions aligned with national initiatives like GERMAS (Healthy Living Movement (GERMAS) and Posbindu PTM, emphasizing smoking cessation, dietary modification, and community-based blood pressure control (72,75). By aligning local evidence with national and WHO regional action frameworks (WHO SEARO, 2022), this study contributes to strengthening Indonesia's noncommunicable disease prevention agenda and provides context-specific insights for developing effective cardiovascular health policies and behavioral interventions (75,76).

However, this study has several limitations. The cross-sectional design limits the causal inference between smoking, obesity, hypertension, lifestyle factors, and CHD. The use of a single hospital as the sampling site may introduce selection bias, and reliance on self-reported questionnaires for smoking and lifestyle behaviors increases the susceptibility to recall bias and social desirability bias. The relatively small sample size further constrains external

validity, limiting the generalization to broader populations with different demographic or behavioral profiles. Additionally, important determinants such as genetic history, psychosocial stress, and blood lipid levels were not included despite their potential influence on CHD risk. These methodological constraints highlight the need for cautious interpretation of the findings and underscore the importance of future studies employing larger, representative, and longitudinal designs to strengthen the evidence for targeted public health interventions and policy planning. Follow-up research needs to use a prospective cohort design for causal relationships to be more robustly explained. The measurement of risk factors should be performed with more objective instruments, such as inflammatory biomarkers, lipid levels, or radiological examinations for the early detection of atherosclerosis. In addition, it is necessary to include a larger and more diverse population to enhance external validity. Intervention studies assessing the effectiveness of smoking cessation programs, obesity control, and lifestyle modifications in reducing CHD incidence are urgently needed.

The findings of this study have significant social implications because CHD is the main cause of morbidity and mortality. Therefore, the results of this study can be the basis for designing public health policies, especially cardiovascular risk factor control programs. Ethically, this study emphasizes the importance of respecting the right of patients to obtain correct information about the risks of unhealthy behavior as well as the responsibility of health workers in providing preventive education that is not discriminatory. With an evidence-based approach, promotive and preventive efforts are expected to improve quality of life and reduce the economic burden of cardiovascular disease.

CONCLUSION

This study aimed to analyze the relationship between modifiable risk factors, namely smoking, obesity, hypertension, and lifestyle, and the incidence of coronary heart disease (CHD) and to identify the most dominant factors among these variables. The results showed that all four factors were significantly related to CHD, with smoking being the strongest variable that could increase the risk of CHD by up to 16 times greater than that of non-smokers.

These results emphasize the importance of comprehensive prevention strategies, including smoking cessation programs, weight control, hypertension management, and the promotion of healthy lifestyles involving health systems and communities. While providing important insights into modifiable CHD risk factors, this study has limitations, such as a cross-sectional design, the use of self-report-based lifestyle data, and a relatively small sample count, and is limited to a single location, limiting generalization. Further research is recommended to use longitudinal designs or interventions with larger and diverse populations, as well as additional risk markers such as lipid profiles and genetic predispositions, to enrich the understanding of CHD and form the basis for more effective public health interventions and clinical practices.

AUTHOR'S CONTRIBUTION STATEMENT

Alfrida Semuel Ra'bung: Conceptualization, Methodology, Writing - Original Draft, Review & Editing. Dwi Yogyo Suswinarto, Akbar Nur, I Kadek Dwi Sarjana: Conceptualization, Methodology, Manuscript review. Nurarifah: Supervision. I Kadek Wartana: Formal analysis, Writing - Original draft, Manuscript review. Sova Evie, Helena Pangaribuan: Validation, Manuscript review. Kadar Ramadhan: Writing - Review & Editing.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

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