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Patterns and Determinants of Non-communicable Diseases Among the Anak Dalam Tribe (SAD) in Hajran and Nyogan Village, Jambi Province

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Abstract
Background: Noncommunicable diseases (NCDs), particularly hypertension and diabetes mellitus (DM), are emerging among the Anak Dalam (SAD) community due to lifestyle changes associated with social transition and settlement. Objective: This study analyzed the patterns and determinants of NCDs among the SAD community in the villages of Nyogan and Hajran, Jambi Province. Methods: We conducted a cross-sectional study in June–July 2026 among all eligible SAD members aged ≥15 years. Data were collected through interviews and physical measurements. Variables included sociodemographic, behavioral, and biological factors. Data were analyzed using chi-square tests and multiple Cox regression with a 95% confidence level. Results: The prevalence of hypertension was 27%, and that of diabetes mellitus (DM) was 3%. Age ≥40 years (PR=2.253; 95% CI: 1.149–4.419) and central obesity (PR=3.356; 95% CI: 1.787–7.075) were associated with the incidence of NCDs. Central obesity was the dominant factor (PR = 4.406; 95% CI: 1.774–10.939) after adjusting for age, sex, and socioeconomic status. Conclusion: The prevalence of NCDs in the SAD community is beginning to resemble that of the general population. Prevention efforts should focus on controlling central obesity through a balanced diet and early detection, particularly among individuals aged ≥40 years and those with other risk factors.

Keywords: Central obesity; Diabetes; Hypertension; Indigenous people; Non-communicable disease; Suku Anak Dalam

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INTRODUCTION

Noncommunicable diseases (NCDs) have overtaken infectious diseases as the dominant cause of death worldwide [1]. The World Health Organization estimates that NCDs, principally cardiovascular disease, cancer, chronic respiratory disease, and diabetes, account for roughly three-quarters of global deaths each year, with cardiovascular disease alone responsible for the largest share [2]. Hypertension and diabetes mellitus (DM) sit at the center of this burden because both are silent, modifiable precursors to stroke, ischemic heart disease, and chronic kidney disease [3]. The most recent International Diabetes Federation atlas estimates that more than 500 million adults lived with diabetes in 2024, projecting a rise to 900 million by 2050, with the steepest increases occurring in low- and middle-income countries as populations age and diets shift away from traditional patterns [4]. This trajectory is not confined to urban, industrialized populations; it is increasingly visible in communities that until recently were considered protected by subsistence lifestyles.

Indonesia illustrates this shift nationally. Hypertension prevalence among Indonesian adults rose from 25.8% in the 2013 Basic Health Survey (Riskesdas) to 34.1% in 2018, and district-level analyses show that this burden is not confined to the wealthiest, most urbanized regions: hypertension prevalence varies substantially by geography, income, and age, with older adults and residents of both affluent and underserved districts carrying disproportionate risk [5,6]. Obesity, a key upstream driver of hypertension and DM, shows a comparable pattern of geographic and socioeconomic inequality across Indonesia's more than 500 districts, with rural and transitional communities no longer exempt from the rising curve [7]. These national data, however, are drawn overwhelmingly from settled, market-integrated populations; Indonesia's indigenous and semi-nomadic communities are structurally underrepresented in the surveys that inform these estimates, leaving their NCD burden largely undocumented [3].

The Suku Anak Dalam (SAD), or Orang Rimba, of Jambi Province exemplify this evidentiary gap. Historically a semi-nomadic, forest-dependent people whose subsistence depended on foraging, hunting, and fishing within customary forest territory, the SAD have experienced accelerating displacement over the past two decades as oil palm concessions, logging, and government resettlement programs have fragmented their traditional land base [8]. Ethnographic and food-security research documents how this dispossession has replaced a once-diverse forest diet with cassava, instant noodles, and other low-cost, low-nutrient market foods, while access to wild game, river fish, and forest tubers has sharply declined [8,9]. This dietary substitution, driven by land loss rather than choice, is a textbook illustration of the nutrition transition: the theoretical framework describing how urbanization, market integration, and the displacement of traditional foodways drive a population from patterns of undernutrition toward diets dominated by energy-dense, ultra-processed foods, with a corresponding rise in obesity, hypertension, and type 2 diabetes [10]. Comparable transitions have been documented among other underrepresented indigenous groups confronting resettlement and market integration, such as indigenous communities in Nepal, where a cross-sectional survey found a hypertension prevalence of 23.8%, associated with age, body mass index, and tobacco use, despite these communities' historically lower cardiometabolic risk profile [11].

Central obesity, rather than general adiposity, appears to be the more proximate and consistent driver of this risk [12]. Evidence from China's Health and Nutrition Survey shows that individuals with normal body mass index but central obesity, measured by waist circumference, still carry a significantly elevated risk of hypertension relative to those without central adiposity, and that this risk compounds further among those who

are both overweight and centrally obese [13]. A parallel analysis using U.S. national data similarly found that normal-weight central obesity elevates diabetes risk independent of overall BMI, reinforcing waist circumference as a superior anthropometric predictor of cardiometabolic disease compared with BMI alone [14]. Age compounds this risk through well-established, cumulative vascular and metabolic changes, a pattern consistently reproduced across both high-income and transitional-economy populations [13,15]. Together, these findings suggest that in populations undergoing rapid dietary and lifestyle change, central adiposity and advancing age may emerge as dominant determinants of NCDs even before classical markers such as overall obesity or high income become apparent, a possibility that remains empirically untested among Indonesia's forest-dependent indigenous populations.

This creates a clear research gap. Much of the existing literature on the SAD has concentrated on food insecurity, land dispossession, and cultural resilience from anthropological and sustainability perspectives [8,9], while Indonesia's national NCD surveillance data, drawn from Riskesdas and similar instruments, systematically exclude semi-nomadic and customary-law communities from their sampling frames [7,15]. As a result, no quantitative, biomarker-based account currently exists of hypertension and DM prevalence, or of their behavioral, sociodemographic, and anthropometric determinants, among the SAD specifically. This gap is consequential: without empirical data, prevention programs designed for the general Indonesian population, which assume market access, health literacy, and health-seeking behavior typical of settled populations, cannot be reliably extended to a community whose engagement with formal health systems, diet, and land tenure differs fundamentally from the national norm.

Addressing this gap is also time-sensitive. As resettlement accelerates and traditional foraging becomes less viable, the SAD are moving further along the nutrition transition curve each year, meaning that current data capture a population still early in this shift rather than one whose NCD burden has already stabilized at higher levels seen elsewhere in Indonesia [16]. Establishing a baseline now provides both a scientific reference point for tracking future change and a practical foundation for designing culturally appropriate screening and prevention strategies before the burden becomes further entrenched. Accordingly, this study aimed to analyze the prevalence patterns and determinants of noncommunicable diseases, specifically hypertension and diabetes mellitus, among the Suku Anak Dalam community in Nyogan and Hajran villages, Jambi Province, with particular attention to sociodemographic, behavioral, and biological factors, including age and central obesity, that may explain the emergence of this burden in a population undergoing rapid social and dietary transition.

METHODS

Study design and setting

This study employed a quantitative cross-sectional design, in which the independent and dependent variables were assessed simultaneously at a single point in time, allowing for the estimation of NCD's (hypertension and DM prevalence) and the identification of their associated determinants. The study was conducted among the Suku Anak Dalam (SAD) indigenous community residing in Hajran Village, Batanghari Regency, and Nyogan Village, Muaro Jambi Regency, Jambi Province, Indonesia. The overall study period spanned 10 months, from conceptualization to dissemination, while primary data collection was carried out over a one-month period in June–July 2026.

Population, samples and sampling

The source population comprised all SAD individuals aged ≥15 years in the two villages, totaling 435 people according to 2025 village-midwife records. Sample size was calculated using a two-proportion hypothesis test ($\alpha = 0.05$; $P1 = 0.27$; $P2 = 0.37$), with a minimum sample number of 163 respondents. A total sampling technique was applied, in which all eligible individuals were approached rather than a random subset. Inclusion criteria were age ≥15 years, SAD ethnicity or first-degree SAD descent (father or mother SAD), and residence in the study area for ≥6 months. Exclusion criteria were refusal to provide informed consent; unavailability during data collection (e.g., engaged in melangun or forest foraging, or family-restricted access); pregnancy; current use of medications known to raise blood pressure (e.g., Proris, Naprosyn, Procold, Rhinos SR, INZA, weight-loss drugs); and alcohol consumption. Because a substantial proportion of the eligible population could not be located during fieldwork (foraging, fishing, or day labor), the final analytic sample was 100 respondents (20 of 232 eligible in Hajran; 80 of 203 eligible in Nyogan). The power of this study was 60.3%. The dependent variable was NCD's (hypertension and/or DM); independent variables were age, sex, household head employment status, socioeconomic status, family history, physical activity, smoking status, risky food consumption, and central obesity.

Instruments and criteria

Sociodemographic and behavioral variables were assessed with an interviewer-administered questionnaire. Physical activity, smoking, and flour-based processed food consumption items were adapted from Indonesia's Basic Health Research (Riskesdas) questionnaires (2013 and 2018 editions); risky food consumption and household socioeconomic indicators followed the 2023 Indonesia Health Survey (Survei Kesehatan Indonesia, SKI) household and individual questionnaires. Dietary diversity, energy intake, and selected nutrient intake were assessed using a semi-quantitative Food Frequency Questionnaire (semi-FFQ) adapted from the 2018 Food Consumption Survey. Blood pressure was measured with a validated digital sphygmomanometer, taken twice at 5-minute intervals after ≥5 minutes of rest in a seated position; a third measurement was taken if the two readings differed by ≥10 mmHg, and the mean of the closest pair was used. Hypertension was defined as systolic blood pressure >140 mmHg and/or diastolic blood pressure> 90 mmHg, based on the results of blood pressure measurements by health workers [17]. Participants were asked to avoid smoking, heavy meals, alcohol, or caffeine for 30 minutes before measurement, and conversation was avoided during readings to minimize measurement error. Diabetes Mellitus is measured based on the results of the examination of blood sugar levels (GDS) using a digital measuring device, with criteria if the GDS level >= 200 mg/dL is indicated as DM. It is said to have a risk of NCD's if the SAD has high blood pressure and/or has a blood sugar level > 200 mg/dL.

Procedure and data collection

Data were collected through face-to-face interviews and direct blood pressure measurement by six trained enumerators, standardized through a two-day training with re-training conducted twice before fieldwork, accompanied by the village midwife and a trusted community intermediary (Waris) to facilitate access and trust within the SAD community.

Statistical analysis

Data were processed through editing, coding, entry, and cleaning before analysis. Univariate analysis described the frequency and percentage of categorical variables and mean, minimum, and maximum for numerical variables. Bivariate analysis examined associations between each independent variable and NCDs using the Chi-

square test, with Fisher's Exact Test applied when expected cell counts were <5, and Continuity Correction applied for 2×2 tables without expected counts <5, at α = 0.05. Multivariable analysis used Cox regression, retaining variables with p<0.25 at the bivariate stage or judged substantively important, with prevalence ratios (PR) and 95% confidence intervals reported; the variable with the highest adjusted prevalence ratio was identified as the dominant determinant [18].

Ethical considerations

The study adhered to core research ethics principles, including informed consent (respondents were informed of the study purpose and voluntarily signed a consent form before participation), anonymity (respondent identity was withheld from data collection sheets and replaced with codes), and confidentiality (all collected information was securely safeguarded by the research team). The ethical feasibility of this research was obtained from the Research Ethics Commission of the Poltekkes Kemenkes Jambi (Health Polytechnic of the Ministry of Health of the Republic of Indonesia) with number: LB.02.06/2/0359/2026 dated 4 Mei 2026.

RESULTS

Table 1 summarizes the distribution of blood pressure and blood glucose status among the study population. When classified using the four-category blood pressure classification, 35.0% of respondents had normal blood pressure, 38.0% were in the prehypertension range, 15.0% had Grade 1 hypertension, and 12.0% had Grade 2 hypertension. Using the binary clinical cut-off (systolic blood pressure >140 mmHg and/or diastolic blood pressure >90 mmHg), the overall prevalence of hypertension in this population was 27.0%, while 73.0% of respondents were classified as non-hypertensive. For blood glucose status, the majority of respondents (87.8%) had normal fasting blood glucose, 9.2% met the criteria for prediabetes, and 3.1% met the criteria for diabetes mellitus. Overall, hypertension emerged as the more prevalent of the two noncommunicable conditions assessed in this population, affecting more than one in four respondents, whereas diabetes mellitus remained comparatively uncommon.

Table 2 presents the sociodemographic, behavioral, and anthropometric characteristics of the study sample. With respect to age, 43.0% of respondents were aged 40 years or older, while 57.0% were younger than 40 years. The sample was predominantly female (83.0%). Educational attainment was generally low: nearly half of respondents (49.0%) had never attended formal schooling, 16.0% had not completed elementary school, 21.0% had completed elementary school, and only 14.0% had progressed beyond the junior secondary level. In terms of occupation, informal agricultural labor was the most common livelihood (53.0%), followed by independent farming (21.0%) and fishing (11.0%), while 10.0% of respondents were not working. Household income was concentrated in the lower brackets: 10.0% earned less than Rp500,000 per month, 13.0% earned IDR. 500,000 to 1,000,000, 19.0% earned IDR.1,000,000 to 1,500,000, 28.0% earned IDR.1,500,000 to 2,500,000, and 30.0% earned IDR. 2,500,000 to 5,000,000. Consistent with this income profile, 90.0% of households had income below the regional minimum wage (Upah Minimum Provinsi, UMP), and most households (77.0%) comprised fewer than five members.

Table 1. Distribution of Blood Pressure and Blood Glucose Status Among Respondents

Variable	n	%
Hypertension		
Normal	35	35.0
Prehypertension	38	38.0

Variable	n	%
Stage 1 Hypertension	15	15.0
Stage 2 Hypertension	12	12.0
Hypertension Status		
Yes	27	27.0
No	73	73.0
Diabetes		
Normal	86	87.8
Prediabetes	9	9.2
Diabetes	3	3.1
Non-Communicable Diseases (NCDs)		
Yes	27	27.0
No	73	73.0

Source: Statistical Analysis, 2026

Regarding behavioral risk factors, 33.0% of respondents reported a history of smoking. Fruit and vegetable intake was markedly insufficient across the sample, with 99.0% of respondents failing to meet recommended consumption levels. Concerning risky food and beverage consumption, more than half of respondents (55.0%) were classified as frequent consumers of risk-associated items such as sweetened foods and beverages, salty foods, flavor-enhancing seasonings (MSG), fatty and grilled foods, preserved foods, and energy drinks, compared with 45.0% classified as infrequent consumers. Notably, 34.0% of respondents consumed sweet foods more than once daily and a further 26.0% consumed them once daily, while 29.0% consumed sweetened beverages more than once daily; salty food consumption of three or more times weekly was reported by 49.0% of respondents, and seasoning/MSG use of at least once daily was reported by 61.0% of respondents, indicating that dietary patterns in this population were already heavily weighted toward energy-dense, high-sodium, and highly processed items.

Central obesity, assessed by waist circumference, was present in 36.0% of respondents and absent in 64.0%. A family history of NCD's was reported by only 4.0% of respondents, while the remaining 96.0% reported no such history.

Table 2. Sociodemographic, Behavioral, and Anthropometric Characteristics of Respondents

Variable	n	%
Age		
≥ 40 years	43	43.0
< 40 years	57	57.0
Gender		
Male	17	17.0
Female	83	83.0
Education Level		
No formal education	49	49.0
Incomplete primary school	16	16.0
Completed primary school	21	21.0
Incomplete junior high school	2	2.0
Completed junior high school	6	6.0
Completed senior high school	6	6.0

Variable	n	%
Occupation		
Farmer	21	21.0
Fisherman	11	11.0
Agricultural laborer	53	53.0
Unemployed	10	10.0
Other	5	5.0
Income		
<Rp.500.000	10	10.0
>Rp.500.000-1.000.000	13	13.0
Rp.1.000.000-1.500.000	19	19.0
Rp.1.500.000-2.500.000	28	28.0
>Rp.2.500.000-5.000.000	30	30.0
Family Size		
≥ 5	23	23.0
<5	77	77.0
Socioeconomic Status		
Below minimum wage	90	90.0
Above minimum wage	10	10.0
Smoking Status		
Smoked	33	33.0
Never smoked	67	67.0
Fruit and Vegetable Consumption		
Inadequate	99	99.0
Adequate	1	1.0
Adolescent Nutritional Status		
Undernourished	1	1.0
Well-nourished	5	5.0
Total	6	6.0
System	94	94.0
Sweet Foods		
> 1 time/day	34	34.0
1 time/day	26	26.0
3–6 times/week	12	12.0
1–2 times/week	13	13.0
< 3 times/month	6	6.0
Never	9	9.0
Sweet Beverages		
> 1 time/day	29	29.0
1 time/day	22	22.0
3–6 times/week	14	14.0
1–2 times/week	16	16.0
< 3 times/month	11	11.0
Never	8	8.0
Salty Foods		
> 1 time/day	20	20.0
1 time/day	18	18.0

Variable	n	%
3–6 times/week	31	31.0
1–2 times/week	18	18.0
< 3 times/month	8	8.0
Never	5	5.0
High-Fat Foods		
> 1 time/day	10	10.0
1 time/day	25	25.0
3–6 times/week	27	27.0
1–2 times/week	29	29.0
< 3 times/month	6	6.0
Never	3	3.0
Grilled Foods		
> 1 time/day	7	7.0
1 time/day	20	20.0
3–6 times/week	21	21.0
1–2 times/week	26	26.0
< 3 times/month	20	20.0
Never	6	6.0
Preserved Foods		
1 time/day	16	16.0
3–6 times/week	8	8.0
1–2 times/week	13	13.0
< 3 times/month	34	34.0
Never	29	29.0
Flavor Enhancers		
> 1 time/day	21	21.0
1 time/day	40	40.0
3–6 times/week	21	21.0
1–2 times/week	8	8.0
< 3 times/month	4	4.0
Never	6	6.0
Soft Drinks		
1 time/day	5	5.0
3–6 times/week	4	4.0
1–2 times/week	9	9.0
< 3 times/month	31	31.0
Never	51	51.0
Energy Drinks		
> 1 time/day	14	14.0
1 time/day	3	3.0
3–6 times/week	18	18.0
1–2 times/week	8	8.0
< 3 times/month	18	18.0
Never	39	39.0
Instant Foods		
> 1 time/day	5	5.0
1 time/day	9	9.0
3–6 times/week	22	22.0

Variable	n	%
1–2 times/week	31	31.0
< 3 times/month	8	8.0
Never	25	25.0
Consumption Pattern		
Frequent	55	55
Infrequent	45	45
Central Obesity		
Yes	36	36
No	64	64
Family History		
Yes	4	4.0
No	96	96.0

Table 3 presents the bivariate associations between sociodemographic, behavioral, and anthropometric variables and the occurrence of NCDs. Age was significantly associated with NCDs: respondents aged 40 years and above had an NCD prevalence of 39.5%, compared with 17.5% among those under 40 years (PR=2.253; 95% CI: 1.149–4.419; p=0.026), indicating that older respondents had more than twice the prevalence of NCDs relative to younger respondents. Central obesity showed the strongest association with NCDs among all variables examined: 50.0% of respondents with central obesity had NCDs, compared with only 14.1% of those without central obesity (PR=3.556; 95% CI: 1.787–7.075; p<0.001). No statistically significant associations were found between NCDs and sex (male 35.3% vs. female 25.3%; PR=1.395; 95% CI: 0.664–2.930; p=0.387), household head employment status (not working 30.0% vs. working 26.7%; PR=1.125; 95% CI: 0.411–3.079; p=1.000), socioeconomic status (below minimum wage 27.8% vs. above minimum wage 20.0%; PR=1.389; 95% CI: 0.385–5.013; p=0.725), family history of NCDs (present 50.0% vs. absent 26.0%; PR=1.920; 95% CI: 0.681–5.412; p=0.294), physical activity level (moderate 28.6% vs. heavy 26.6%; PR=1.075; 95% CI: 0.498–2.319; p=1.000), smoking status (smoker 27.3% vs. non-smoker 26.9%; PR=1.015; 95% CI: 0.513–2.010; p=1.000), or risky food consumption pattern (frequent 27.3% vs. infrequent 26.7%; PR=1.023; 95% CI: 0.535–1.957; p=1.000). Although these associations did not reach statistical significance, the comparatively wide confidence intervals, particularly for family history (0.681–5.412) and sex (0.664–2.930), suggest that the available sample size may have been insufficient to detect true associations of modest magnitude for these variables.

Table 3. Bivariate Analysis of Factors Associated with NCDs Among the SAD Community

Variable	Hypertension Yes n	Hypertension Yes %	Hypertension No n	Hypertension No %	Total n	Total %	PR (95% CI)	P-Value
Age								
≥ 40 years	17	39.5	26	60.5	43	100.0	2.253 (1.149–4.419)	0.026
< 40 years	10	17.5	47	82.5	57	100.0		
Gender								
Male	6	35.3	11	64.7	17	100.0	1.395 (0.664–2.930)	0.387
Female	21	25.3	62	74.7	83	100.0		

Variable	Hypertension Yes n	Hypertension Yes %	Hypertension No n	Hypertension No %	Total n	Total %	PR (95% CI)	P-Value
Head of Household's Occupation								
Unemployed	3	30.0	7	70.0	10	100.0	1.125 (0.411–3.079)	1.000
Employed	24	26.7	66	73.3	90	100.0		
Socioeconomic Status								
Below minimum wage	25	27.8	65	72.2	90	100.0	1.389 (0.385–5.013)	0.725
Above minimum wage	2	20.0	8	80.0	10	100.0		
Family History	Family History							
Yes	2	50.0	2	50.0	4	100.0	1.920 (0.681–5.412)	0.29417
No	25	26.0	71	74.0	96	100.0		
Physical Activity								
Moderate	6	28.6	15	71.4	21	100.0	1.075 (0.498–2.319)	1.000
Vigorous	21	26.6	58	73.4	79	100.0		
Smoking Status								
Smoked	9	27.3	24	72.7	33	100.0	1.015 (0.513–2.010)	1.000
Never smoked	18	26.9	49	73.1	67	100.0		
Risky Dietary Pattern	Risky Dietary Pattern	Risky Dietary Pattern						
Frequent	15	27.3	40	72.7	55	100.0	1.023 (0.535–1.957)	1.000
Infrequent	12	26.7	33	73.3	45	100.0		
Central Obesity								
Yes	18	50.0	18	50.0	36	100.0	3.556 (1.787–7.075)	0.000
No	9	14.1	55	85.9	64	100.0		

Table 4 presents the results of the multivariate analysis of determinants of hypertension. Variables with a bivariate p-value <0.25 (age, sex, household head employment, socioeconomic status, family history of NCDs, and physical activity) were entered into a Cox regression model together with central obesity, which was retained on substantive grounds given its strong bivariate association. Household head employment status, family history of NCDs, and physical activity were sequentially removed across successive modeling steps, as their exclusion did not alter the adjusted prevalence ratio (PR) of the remaining variables by more than 10%. The final model retained four variables: age, sex, socioeconomic status, and central obesity.

Table 4. Multivariate Analysis of Determinants of NCDs: Final Model

Variable	B	P-Value	PR (95% CI)	Omnibus P-value
Age	0.501	0.213	1.650 (0.750–3.631)	0.003

Variable	B	P-Value	PR (95% CI)	Omnibus P-value
Gender	0.960	0.071	2.611 (0.920–7.405)	
Socioeconomic Status	0.744	0.329	2.104 (0.472–9.385)	
Central Obesity	1.483	0.001	4.406 (1.774–10.939)	

In the final adjusted model, central obesity remained the strongest and only statistically significant determinant of NCDs (adjusted PR=4.406; 95% CI: 1.774–10.939; p=0.001), indicating that, after controlling for age, sex, and socioeconomic status, respondents with central obesity had more than four times the prevalence of NCDs compared with those without central obesity. Age 40 years and above (adjusted PR=1.650; 95% CI: 0.750–3.631; p=0.213), male sex (adjusted PR=2.611; 95% CI: 0.920–7.405; p=0.071), and socioeconomic status below the regional minimum wage (adjusted PR=2.104; 95% CI: 0.472–9.385; p=0.329) were retained in the final model as covariates but did not reach statistical significance after adjustment, although the association for sex approached the conventional significance threshold. The overall model was statistically significant (omnibus test, p=0.003), confirming adequate model fit, and central obesity was identified as the dominant determinant of NCDs in this population, having the highest adjusted PR among all variables retained in the final model.

Taken together, these findings indicate that although the SAD community in Hajran and Nyogan retains sociodemographic characteristics historically associated with subsistence livelihoods, such as low educational attainment, informal agricultural occupations, and household income below the regional minimum wage, its pattern of noncommunicable disease risk already resembles that observed in settled, market-integrated Indonesian populations. Central obesity and older age emerged as the principal drivers of NCDs in this population, while classical socioeconomic and behavioral markers, including smoking, physical activity, and risky food consumption patterns as a composite measure, did not show statistically significant associations once analyzed individually.

DISCUSSION

The present findings both extend and complicate the existing literature on NCD risk among transitioning indigenous populations. The overall NCD proportion of 27% among the Suku Anak Dalam (SAD) sits below Indonesia's national adult prevalence of 34.1% reported in the 2018 Basic Health Survey [6], suggesting the SAD have not yet reached the cardiometabolic burden of the general population, yet it substantially exceeds the 23.8% reported among an underrepresented indigenous group in Nepal [11], indicating that semi-nomadic and resettled communities are not uniformly protected from rising blood pressure [19]. The identification of central obesity as the dominant determinant, more than quadrupling the prevalence of NCD after adjustment, coheres closely with evidence from China's Health and Nutrition Survey and United States national data showing that waist circumference, rather than overall body mass index, is the more proximate anthropometric predictor of hypertension and diabetes risk, even among individuals of normal weight [13,14,17]. The association between age 40 years and above and hypertension likewise mirrors the cumulative vascular risk pattern documented across both high-income and transitional-economy settings [13,15,20]. However, the absence of statistically significant associations for smoking, physical activity, risky food consumption pattern, and socioeconomic status contrasts with much of the regional NCD literature, where these behavioral and

structural factors are typically implicated [7,15]. This divergence may reflect genuine differences in this population's risk profile, since near-universal physical labor may compress the observable range of physical activity, but it may equally reflect the modest sample size (n=100) and the correspondingly wide confidence intervals surrounding these null estimates, limiting the ability to rule out true associations of moderate magnitude. The composite construction of the risky food consumption variable may also have obscured the effects of specific dietary items, such as energy drinks or flavoring agents, that other studies in the region have found to be more discriminating markers of dietary risk than an aggregate index. Overall, the central obesity and age findings cohere with the broader nutrition-transition literature, while the null behavioral findings should be read as inconclusive rather than as evidence of a true absence of association [21,22].

The objectives of this study, to characterize the prevalence and determinants of hypertension and diabetes among the SAD, were explicitly framed within Popkin's nutrition transition framework, which describes how the erosion of traditional foodways under market integration and urbanization drives a shift from undernutrition toward energy-dense diets and rising rates of obesity and NCDs [10]. This framing is theoretically apt for the SAD, whose forest-dependent subsistence economy has been displaced by oil palm expansion, logging, and resettlement, replacing a once-varied forest diet with low-cost, low-nutrient market foods [8,9,23] [5,6]. The research gap motivating this study is well established: Indonesia's national NCD surveillance instruments, including Riskesdas and the Indonesia Health Survey, systematically exclude semi-nomadic and customary-law communities from their sampling frames [7,15], while the existing literature on the SAD has concentrated on food insecurity and land dispossession from anthropological and sustainability perspectives rather than quantitative, biomarker-based epidemiology [8,9]. Consequently, no empirical account previously existed of hypertension or diabetes prevalence, or of their sociodemographic, behavioral, and anthropometric determinants, in this population. The state of the art on central obesity as an independent determinant of overall body mass index [13,14] provided a specific, testable hypothesis that this study was positioned to evaluate in a population not previously studied. The urgency of the work follows from the observation that resettlement is accelerating and the SAD are moving further along the nutrition transition curve each year, meaning that a baseline established now captures a population still early in this shift rather than one whose NCD burden has already stabilized. The novelty of this study lies in providing the first quantitative, biomarker-based estimate of NCD burden and its determinants among the SAD, directly addressing the surveillance gap left by national instruments [7,15] and testing, in an indigenous forest-dependent population, whether central obesity operates as a dominant determinant as it does in more extensively studied settings [13,14]. In doing so, the study extends the nutrition transition framework [10] to a population at an earlier and less-documented stage of transition, offering an empirical foundation that existing NCD prevention policies, designed around settled populations, have so far lacked for extension to indigenous, semi-nomadic communities.

These findings carry direct implications for practitioners and health administrators responsible for NCD prevention among indigenous and hard-to-reach populations. For practitioners, the dominance of central obesity as a determinant, independent of overall body mass index, argues for incorporating waist circumference measurement, not body mass index alone, into routine screening among the SAD and similar populations, consistent with evidence that normal-weight central obesity carries

elevated cardiometabolic risk that body-mass-index-based screening would miss [13,14]. The concentration of NCD among those aged 40 years and above further suggests that opportunistic screening during any community contact, rather than reliance on scheduled visits, should prioritize this age group, given that only 16% of respondents in this study reported routine blood pressure checks and over a third had never been measured before. For administrators, Indonesia's community-based Posbindu PTM screening program provides an existing platform, but evaluations have shown that its reach and follow-through are uneven even in settled populations, with barriers including limited resources, cadre capacity, and low coverage of younger adults and men [24]. Extending Posbindu-style screening to semi-nomadic communities such as the SAD will likely require further adaptation, since standard scheduling assumes a fixed and reachable population, whereas this study itself could only enroll 100 of 435 eligible SAD residents because many were engaged in forest foraging, fishing, or day labor during data collection. Models that pair trained community health workers with a trusted community intermediary, as used in this study, and that bring blood pressure monitoring directly into households rather than requiring clinic attendance have demonstrated meaningful blood pressure reductions in comparable rural, resource-limited settings [25], and could inform a culturally adapted screening and follow-up protocol for the SAD. Policymakers should also consider that prevention programs calibrated to market-integrated populations, which assume health literacy and health-seeking behavior typical of settled communities, cannot be directly extended to the SAD without accounting for their distinct land tenure, mobility, and health system engagement patterns. Embedding waist circumference screening and mobile, intermediary-supported outreach into any future Posbindu expansion targeting the SAD would represent a concrete, evidence-informed policy step.

Several features of this study warrant caution in generalizing its findings beyond the immediate study population. First, the sample was drawn from only two villages, Hajran and Nyogan, within a single province, and the two sites differed in both size and representativeness: only 20 of 232 eligible individuals in Hajran and 80 of 203 eligible individuals in Nyogan could be reached, with non-participation concentrated among those engaged in forest foraging (melangun), fishing, or day labor. Because these unreached individuals may differ systematically in diet, physical activity, or health status from those who were available, the reported prevalence estimates should be interpreted as characterizing the reachable, more settled segment of the SAD population rather than the full community. Second, the cross-sectional design precludes causal or temporal inference: it cannot establish whether central obesity precedes hypertension onset in this population or whether both instead share upstream drivers such as dietary transition, and reverse causal pathways cannot be excluded. Third, the SAD are not a homogeneous group; subgroups with differing degrees of resettlement, forest access, and market integration exist across Jambi Province and neighboring regions, and the Hajran-Nyogan findings should not be extrapolated to more remote or more thoroughly resettled SAD communities without further study. Finally, while the association between central obesity and NCD is consistent with evidence from other transitioning and non-indigenous populations [13,14], the specific magnitude of this association in the SAD should be treated as a population-specific estimate rather than a universal parameter, and replication with a larger, multi-site, longitudinal sample is needed before these findings inform national indigenous health policy.

CONCLUSIONS

This study aimed to characterize the prevalence and determinants of hypertension and diabetes mellitus among the Suku Anak Dalam (SAD) community in Hajran and Nyogan villages, Jambi Province. The findings show that hypertension prevalence has reached 27%, while diabetes mellitus remains comparatively low at 3%, indicating that this semi-nomadic, forest-dependent population is already experiencing a noncommunicable disease burden approaching that of settled, market-integrated Indonesian populations. Central obesity emerged as the dominant determinant of NCD, more than quadrupling prevalence after adjustment for age, sex, and socioeconomic status, while age ≥40 years also showed a significant unadjusted association. Classical behavioral and socioeconomic markers, including smoking, physical activity, and risky food consumption, did not reach statistical significance. These results confirm that the SAD community is undergoing an early-stage nutrition transition, with anthropometric rather than behavioral or socioeconomic factors currently driving NCD risk in this understudied population.

It is recommended that the SAD community maintain a diet by implementing a balanced diet and CERDIK behavior to prevent NCDs. The government, through the PUSKESMAS, can conduct health screening for the SAD community by checking blood pressure, blood sugar levels, and measuring nutritional status (abdominal circumference measurement) regularly, especially in men who are > 40 years old through the PTM Posbindu. Future research should pursue larger, multi-site, longitudinal studies across more remote and more thoroughly resettled SAD subgroups to confirm these determinants, establish causal pathways, and evaluate culturally adapted screening approaches, such as mobile, intermediary-supported outreach incorporating waist circumference measurement, before findings are generalized to inform national indigenous health policy.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

This study used artificial intelligence (AI) tools and methodologies in the following capacities:

Manuscript writing support: AI-based language models, such as Claude and ChatGPT were/was employed for language refinement (improving the grammar, sentence structure, and readability of the manuscript), content summarization (assisting in summarizing the findings and conclusions), and technical writing assistance (providing suggestions for structuring complex technical descriptions more effectively).

We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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