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Association of Age, Body Mass Index, and Insurance Type with Blood Pressure Control among Hypertensive Patients

A Cross-Sectional Study

[1]M. Irvan Zufar, [1]Yusuf Alam Romadhon*
Corresponding Author: * yar245@ums.ac.id
[1] Universitas Muhammadiyah Surakarta, Surakarta, Indonesia

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ABSTRACT

Uncontrolled blood pressure remains common in primary care, and payment at the point of care may be associated with differences in blood pressure control. This study examined the associations of age, body mass index (BMI), and visit-level payment category with blood pressure control among adults with primary hypertension in Bendosari District, Sukoharjo, Indonesia. This cross-sectional study used routine medical records from community health centres between January and December 2024. The analysis included 1,492 patients. Blood pressure was classified as uncontrolled if systolic pressure was at least 140 mmHg or diastolic pressure was at least 90 mmHg, or both. Age was categorised at 45 years and BMI at 23 kg/m^2. Payment at the index visit was classified as Jaminan Kesehatan Nasional (JKN) or self-pay. Modified Poisson regression with robust variance estimated adjusted prevalence ratios (aPRs) and 95% confidence intervals (CIs). Uncontrolled blood pressure was recorded in 1,332 patients (89.3%). Compared with JKN payment, self-pay was associated with a higher prevalence of uncontrolled blood pressure (aPR 1.069, 95% CI 1.026–1.115, *p* = 0.002). Associations were not statistically significant for age ≥45 years (aPR 0.999, 95% CI 0.944–1.058, *p* = 0.976) or BMI ≥23 kg/m^2 (aPR 1.022, 95% CI 0.985–1.060, *p* = 0.253). The observed association reflects payment at the recorded encounter. Its interpretation is limited by the cross-sectional design, limited covariate adjustment, uncertainty about blood pressure measurement procedures, and the absence of verified insurance enrolment data. The findings support further investigation of payment and continuity of care.

Keywords
Age
Body mass index
Blood pressure control
Health insurance
Hypertension

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Introduction

Hypertension is a leading modifiable risk factor for cardiovascular disease, stroke, and chronic kidney disease. The World Health Organization estimates that approximately 1.4 billion adults aged 30–79 years live with hypertension globally, while control remains inadequate [1]. Reviews and international pooled analyses document persistent gaps in treatment and control, particularly in low- and middle-income settings [2], [3], [4]. In Indonesia, the 2023 Indonesian Health Survey reported hypertension prevalence of 30.8% among adults aged ≥18 years [5], underscoring the burden on primary care.

Blood pressure control among hypertensive patients is determined by a complex interaction of biological, anthropometric, behavioural, and health-system factors. In Indonesian community health centres (Puskesmas), a large proportion of patients receiving antihypertensive treatment still fail to reach recommended blood pressure targets. Medication non-adherence, insufficient lifestyle modification, and structural gaps in healthcare utilisation have been consistently identified as principal contributing factors [2], [6]. National population-based studies also document gaps in hypertension care and socioeconomic inequalities in Indonesia [7], [8]. These population-level findings provide context but should not be treated as directly comparable estimates for patients attending primary care.

Age is relevant to hypertension management because advancing age is accompanied by arterial stiffening and altered vascular regulation [9]. Age-specific differences in treatment and hypertension care have also been reported [10], [11]. Biological changes and differences in care may operate in different directions, so the association between age and blood pressure control cannot be assumed to be uniform across settings.

Excess adiposity can elevate blood pressure through activation of the renin–angiotensin–aldosterone system, sympathetic activation, insulin resistance, and sodium retention [12]. However, associations between BMI and blood pressure control among hypertensive populations vary. United States survey data showed lower control among adults with normal BMI than among those with overweight or obesity [13], whereas an Iranian nationwide study found higher adjusted odds of uncontrolled hypertension with overweight and obesity [14]. These contrasting findings support evaluating BMI in the local hypertensive population rather than extrapolating directly from evidence on hypertension incidence.

From a healthcare-access perspective, financing may be relevant to blood pressure control because medicine costs and access to primary care can affect continuity of treatment [15], [16]. Health insurance enrolment was associated with better adherence and control in primary-care settings in Nigeria and Ghana [15], but an Indian household fixed-effects study found no significant benefit for the hypertension care cascade after household adjustment [17]. In Indonesia, evaluations of chronic disease management and medicine access indicate that financing, effective programme participation, and continuity of supply are distinct aspects of care [18], [19], [20]. These findings motivate studying visit-level payment category without assuming that it captures all dimensions of insurance or access.

Bendosari District, Sukoharjo Regency, Central Java, is described as a setting with mixed agrarian and semi-urban characteristics [21]. In an urban–rural transition setting, differences in daily activities and access to healthcare could be relevant to adiposity and opportunities for regular hypertension follow-up across age groups. These contextual pathways provide a rationale for considering individual-level characteristics alongside healthcare-access factors, but they were not directly measured in the present study.

Accordingly, this study focused on age and BMI as routinely recorded demographic and anthropometric characteristics, and insurance type as a healthcare-financing-related characteristic operationalised through payment at the index visit. Together, these variables permit a focused examination of complementary individual-level and financing-related domains; their selection does not imply that they are the only or most important determinants. Medication use, adherence, clinical history, and lifestyle remain important but were not included in the primary model [2], [6]. The objective was to examine the associations of age, BMI, and insurance type, measured as visit-level payment category, with blood pressure control among hypertensive patients in Bendosari District, rather than to rank determinants or establish causal effects.

Material and Methods

A. Study Design and Settings

This study used a cross-sectional analytic design based on retrospective review of routinely collected records. “Retrospective” refers to the use of existing records, whereas “cross-sectional” refers to the analysis of one index-visit observation per patient, without longitudinal follow-up. Reporting was informed by the STROBE recommendations [22]. Data were extracted from medical records and the primary healthcare information systems of all community health centres (Puskesmas) in Bendosari District, Sukoharjo Regency, Central Java, Indonesia, covering the period from January to December 2024. Bendosari District comprises fourteen villages, namely Bendosari, Cabeyan, Gentan, Jagan, Jombor, Manisharjo, Mertan,

Mojorejo, Mulur, Paluhombo, Puhgogor, Sidorejo, Sugihan, and Toriyo, and exhibits mixed peri-urban and agrarian characteristics.

To visualise the geographical distribution of blood pressure control, the proportion of patients with uncontrolled blood pressure was aggregated for each of the 14 villages and displayed as a choropleth map. Village administrative boundaries were obtained from the Database of Global Administrative Areas (GADM) version 4.1, using the WGS84 geographic coordinate system [23]. Villages were classified into five percentile categories (<20th, 20th-40th, 40th-60th, 60th-80th, and >80th percentile) based on their relative ranking within the district, and the number of hypertensive patients per village was represented by proportionally scaled point symbols. This mapping was descriptive in nature and was not accompanied by formal spatial statistical testing.

B. Participants and Sampling

Total sampling was applied to the available extraction of potentially eligible hypertensive patients recorded during January–December 2024. Each participant contributed one record; according to the extraction procedure, the first visit in the study year was selected when a patient had multiple visits. The inclusion criteria were a registered diagnosis of primary hypertension, age ≥18 years, residence in one of the fourteen villages of Bendosari District, and complete usable data on the primary study variables. Secondary and gestational hypertension were not eligible. The available intermediate extraction contained 1,862 records. Restriction to records coded as I10 (essential [primary] hypertension) retained 1,494 records; records coded as Z00, Z00.0, or Z01.7 were not included. One record with an implausible recorded height of 55 cm and one with missing systolic blood pressure were excluded, leaving 1,492 records for complete-case analysis; no imputation was used. Two transcription errors in retained records were corrected after verification by the authors: age 17 to 18 years and systolic blood pressure 16 to 160 mmHg. The derivation of the intermediate extraction from the full visit-level source, including the reported first-visit selection, could not be independently reconstructed for every participant from the analysis sheets.

C. Operational Definitions of Variables

Three independent variables were examined. Age was categorised as <45 and ≥45 years to retain the study's original younger-versus-older adult comparison. This was a pragmatic analytic grouping, not a universal clinical threshold for blood pressure control. Because this grouping can lose information and most patients were aged ≥45 years, age was also examined continuously in a sensitivity analysis [24]. BMI was calculated as weight in kilograms divided by squared height in metres and categorised as <23 or ≥23 kg/m^2. The threshold of 23 kg/m^2 is a potential public-health action point identified by a WHO expert consultation for Asian populations, rather than the universal WHO definition of overweight [25]. Conventional BMI

categories (<18.5, 18.5–<25, 25–<30, and ≥30 kg/m^2) and continuous BMI were additionally examined. Insurance type was operationalised as the payment category recorded at the index visit, defined as the patient's first visit during January–December 2024. "JKN-PBI," "JKN-Mandiri," and "JKN-ASKES" were grouped as JKN; "Umum" and "Umum Fakes Luar" were grouped as self-pay. No other payment labels occurred in the analysed records. Self-pay denoted out-of-pocket payment for that encounter and did not establish absence of insurance. Insurance ownership outside that encounter was not verified. Controlled blood pressure required systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg; uncontrolled blood pressure was systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, consistent with the Indonesian national hypertension consensus [26].

Blood pressure classification was based on the systolic and diastolic values recorded at each patient's first visit during January–December 2024. The analytical dataset did not specify the measurement device, patient positioning, rest period, or number of measurements, nor whether the recorded values represented a single reading or an average of repeated readings. Antihypertensive treatment status was not available in the analytical dataset; therefore, treatment could not be verified for all participants.

D. Statistical Analysis

Descriptive analyses summarised categorical variables as counts and percentages and continuous age and BMI as mean ± standard deviation. Bivariate associations were assessed with Pearson's Chi-square test without continuity correction. Separate Poisson models with a log link and robust sandwich variance estimated crude prevalence ratios (PRs) and 95% confidence intervals (CIs). Because uncontrolled blood pressure was common, modified Poisson regression was used instead of logistic regression to estimate adjusted prevalence ratios (aPRs), avoiding interpretation of odds ratios as prevalence ratios [27], [28]. Age category, BMI category, and payment category were entered simultaneously as the three factors specified in the study objective, rather than selected using bivariate significance. Their aPRs are adjusted only for the other included factors. Reference categories were age <45 years, BMI <23 kg/m^2, and JKN payment; uncontrolled blood pressure was coded as 1. Numerical convergence, design-matrix rank, variance inflation factors (VIFs), and fitted-value ranges were checked. Robust variance was computed at the individual-record level, not clustered by facility or village. Exploratory sensitivity analyses used conventional BMI categories, continuous age (per 10 years) and BMI (per 5 kg/m^2), and additional adjustment for recorded sex; these did not replace the primary model. Descriptive and Chi-square analyses used IBM SPSS Statistics version 25; revised PR models were fitted in Python using NumPy, with HC0 sandwich variance and two-sided Wald tests. Statistical significance was defined as $p < 0.05$. These were association models, not validated prediction models.

E. Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable national research regulations. It was undertaken as a sub-analysis within the parent research project entitled "Analysis of Risk Factors for Non-Communicable Diseases in the Industry–Agriculture Transition Area of Sukoharjo", conducted at the primary health centres of Grogol, Bendosari, Mojolaban, and Gatak Districts, for which ethical clearance was granted by the Health Research Ethics Committee of Dr. Moewardi General Hospital, Surakarta, Indonesia (No. 1.609/VII/HREC/2025, issued 21 July 2025). The second author served as the principal investigator of the parent project and authorised the use of the dataset for the present analysis. Because the study used routinely collected secondary data from medical records, the requirement for individual informed consent was waived. All patient records were anonymised using research codes before analysis, and the data were used exclusively for research purposes.

Results

A. Characteristics of Study Subjects

Of the 1,492 hypertensive patients included in the analysis, the majority were aged 45 years or older (90.0%, n=1,343), had BMI ≥23 kg/m^2 (60.3%, n=900), and had their index visits paid through JKN (89.8%, n = 1,340). Uncontrolled blood pressure was identified in 1,332 patients (89.3%), whereas only 160 patients (10.7%) achieved controlled blood pressure. The mean age was 59.11 ± 11.27 years, and the mean BMI was 24.44 ± 4.37 kg/m^2. The complete distribution of subject characteristics is presented in Table 1.

Table 1. Distribution of subject characteristics (n = 1,492)

Variable	Category	n	%
Age (years), mean ± SD	59.11 ± 11.27	-	-
Age	<45 years	149	10.0
	≥45 years	1,343	90.0
BMI (kg/m^2), mean ± SD	24.44 ± 4.37	-	-
Body mass index	<23 kg/m^2	592	39.7
	≥23 kg/m^2	900	60.3
Payment category at the index visit	JKN	1,340	89.8
	Self-pay	152	10.2
Blood pressure control	Controlled (SBP <140 and DBP <90 mmHg)	160	10.7
	Uncontrolled (SBP ≥140 and/or DBP ≥90 mmHg)	1,332	89.3

Source: Secondary data from medical records, 2024. SBP = systolic blood pressure; DBP = diastolic blood pressure; JKN = Jaminan Kesehatan Nasional (Indonesian national health insurance). BMI = body mass index; SD = standard deviation. Continuous values are presented as mean ± SD. Payment category refers to the method of payment recorded at the index visit. Self-pay does not necessarily indicate absence of health insurance. BMI categories in the primary analysis indicate values below or at/above the 23 kg/m^2 action point, not conventional international overweight/obesity classes.

Fig. 1 provides a supplementary descriptive overview of blood pressure control across the 14 villages of Bendosari District, placing the study population in its local geographical context. This mapping complements the main analyses of age, BMI, and payment category; it was not used to test spatial clustering or associations between village of residence and blood pressure control. Uncontrolled blood pressure was pervasive throughout the district, with village-level proportions ranging narrowly from 86.5% to 94.2%. The highest proportions of uncontrolled blood pressure were recorded in Puhgogor (65/69, 94.2%), Cabeyan (45/48, 93.8%), and Mojorejo (27/29, 93.1%), all located in the eastern part of the district, whereas the lowest proportions were observed in Toriyo (134/155, 86.5%), Mulur (206/238, 86.6%), and Paluhombo (60/69, 87.0%). These fractions indicate the number of patients with uncontrolled blood pressure divided by the total number of patients included from each village. Notably, villages contributing the largest numbers of patients tended to show slightly lower proportions of uncontrolled blood pressure, while villages with the smallest patient counts showed the highest proportions. Because the absolute range across villages was less than eight percentage points, the percentile categories displayed in Fig. 1 should be interpreted as relative rankings within the district rather than as indicators of substantively different levels of control. Village-specific counts and percentages are presented in Table 2.

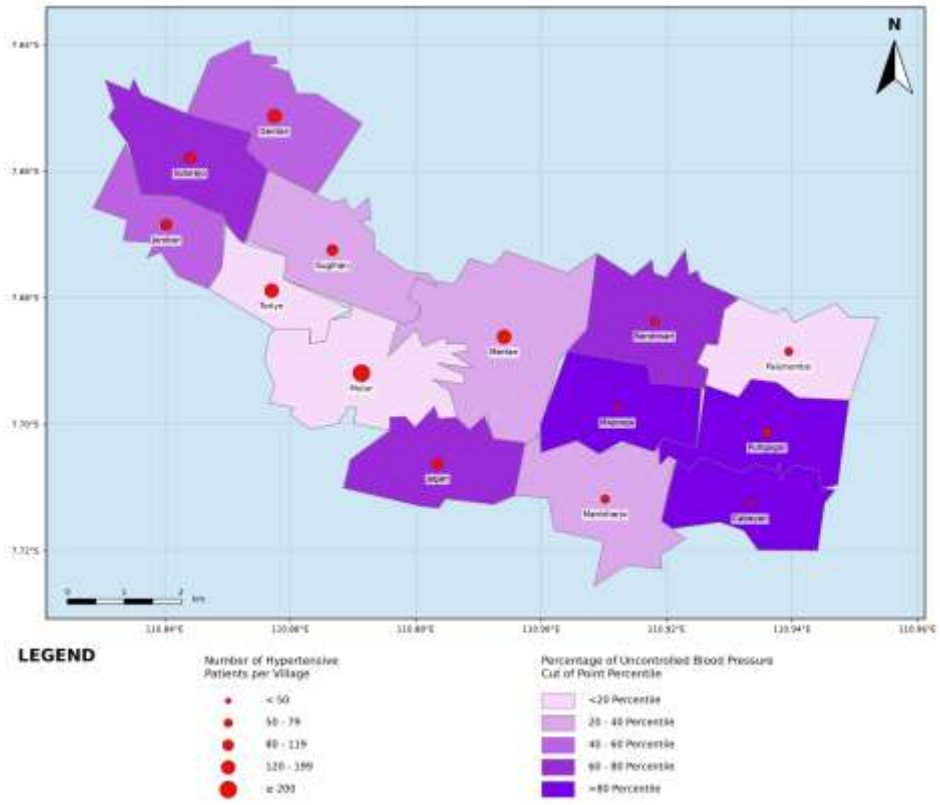

Fig. 1. Spatial distribution of uncontrolled blood pressure among hypertensive patients across 14 villages in Bendosari District, Sukoharjo Regency, Central Java, Indonesia (n = 1,492). Village boundaries were obtained from GADM version 4.1.

Table 2. Distribution of uncontrolled blood pressure by village (N = 1,492)

Village	Total patients (N)	Uncontrolled BP (n)	Uncontrolled BP (%)
Bendosari	58	53	91.4
Cabeyan	48	45	93.8
Gentan	152	136	89.5
Jagan	84	78	92.9
Jombor	105	95	90.5
Manisharjo	74	66	89.2
Mertan	191	170	89.0
Mojorejo	29	27	93.1
Mulur	238	206	86.6
Paluhombo	69	60	87.0
Puhgogor	69	65	94.2
Sidorejo	110	100	90.9
Sugihan	110	97	88.2
Toriyo	155	134	86.5
Total	1,492	1,332	89.3

BP = blood pressure; N = total patients included from each village; n = patients with uncontrolled blood pressure. Percentages were calculated as n/N × 100. Counts are based on the final analytical sample of 1,492 patients.

B. Bivariate Analysis

The results of the bivariate analyses are shown in Table 3. Age category was not significantly associated with uncontrolled blood pressure in the Chi-square analysis ($\chi^2 = 0.075$; $p = 0.785$). The prevalence of uncontrolled blood pressure was 89.9% among patients aged <45 years and 89.2% among those aged ≥45 years. The crude PR for age ≥45 versus <45 years was 0.992 (95% CI 0.937–1.050). BMI category was also not significantly associated with uncontrolled blood pressure in the Chi-square analysis ($\chi^2 = 1.241$; $p = 0.265$). The corresponding prevalences were 88.2% for BMI <23 kg/m^2 and 90.0% for BMI ≥23 kg/m^2, with a crude PR of 1.021 (95% CI 0.984–1.059). Payment category at the index visit was associated with uncontrolled blood pressure in the Chi-square analysis ($\chi^2 = 5.271$; $p = 0.022$). Uncontrolled blood pressure was recorded in 144/152 self-pay patients (94.7%) and 1,188/1,340 patients whose visits were paid through JKN (88.7%). The crude prevalence ratio for self-pay versus JKN was 1.069 (95% CI 1.025–1.115), indicating a modest relative difference in prevalence rather than a more than twofold difference.

Table 3. Bivariate associations of age, BMI, and payment category at the index visit with uncontrolled blood pressure (n = 1,492)

Variable / Category	Controlled n (%)	Uncontrolled n (%)	p (Chi-square)	Crude PR	95% CI
Age			**0.785**		
<45 years (ref.)	15 (10.1)	134 (89.9)		1.000	Reference
≥45 years	145 (10.8)	1,198 (89.2)		0.992	0.937–1.050
Body mass index			**0.265**		
<23 kg/m^2 (ref.)	70 (11.8)	522 (88.2)		1.000	Reference

Variable / Category	Controlled n (%)	Uncontrolled n (%)	p (Chi-square)	Crude PR	95% CI
≥23 kg/m^2	90 (10.0)	810 (90.0)		1.021	0.984–1.059
Payment category			**0.022***		
JKN (ref.)	152 (11.3)	1,188 (88.7)		1.000	Reference
Self-pay	8 (5.3)	144 (94.7)		1.069	1.025–1.115

PR = prevalence ratio for uncontrolled blood pressure; CI = confidence interval; ref. = reference category. Percentages are row-based. Crude PRs and 95% Cis were estimated using separate Poisson regression models with a log link and robust sandwich variance. P values are from Chi-square tests; * statistically significant at p<0.05.

C. Multivariable Analysis

The results of the modified Poisson regression analysis with robust sandwich variance are presented in Table 4. Age category, BMI category, and payment category at the index visit were included simultaneously in the model. Self-pay was associated with a higher prevalence of uncontrolled blood pressure than JKN payment after adjustment for age and BMI categories (aPR = 1.069; 95% CI 1.026–1.115; p = 0.002). Neither age ≥45 versus <45 years (aPR = 0.999; 95% CI 0.944–1.058; p = 0.976) nor BMI ≥23 versus <23 kg/m^2 (aPR = 1.022; 95% CI 0.985–1.060; p = 0.253) was significantly associated with uncontrolled blood pressure.

Table 4. Adjusted prevalence ratios for uncontrolled blood pressure from modified poisson regression (n = 1,492)

Variable / comparison	aPR	95% CI	P
Age ≥45 vs <45 years	0.999	0.944–1.058	0.976
BMI ≥23 vs <23 kg/m^2	1.022	0.985–1.060	0.253
Self-pay vs JKN payment	1.069	1.026–1.115	0.002*

aPR = adjusted prevalence ratio; CI = confidence interval. Estimates were obtained using modified Poisson regression with a log link and robust sandwich variance. Age category, BMI category, and payment category at the index visit were included simultaneously. Reference categories were age <45 years, BMI <23 kg/m^2, and JKN payment. P values are from two-sided Wald tests; * statistically significant at p<0.05.

The primary model converged with a full-rank design matrix; VIFs ranged from 1.004 to 1.012. Fitted prevalences ranged from 0.875 to 0.957, with none above 1. Conventional BMI-category results are shown in Table 5. In sensitivity analyses (Table 6), the adjusted prevalence ratio for self-pay remained similar across models (aPR 1.069–1.071). Continuous age (per 10-year increase; aPR 0.997, 95% CI 0.981–1.013; p = 0.702), continuous BMI (per 5 kg/m^2 increase; aPR 1.013, 95% CI 0.994–1.033; p = 0.166), and recorded sex (female vs male; aPR 0.972, 95% CI 0.938–1.008; p = 0.127) were not statistically significantly associated with uncontrolled blood pressure in their respective models. All sensitivity models converged; one fitted prevalence exceeded 1 in the continuous-BMI model. These models were retained as sensitivity analyses and not for individual prediction.

Table 5. Conventional BMI categories and uncontrolled blood pressure (n = 1,492)

BMI (kg/m²)	Total n (%)	Uncontrolled n (%)	aPR (95% CI)	P
Underweight (<18.5)	73 (4.9)	66 (90.4)	1.023 (0.946–1.106)	0.564
Normal weight (18.5–<25)	901 (60.4)	794 (88.1)	1.000 (reference)	—
Overweight (25–<30)	383 (25.7)	347 (90.6)	1.028 (0.987–1.070)	0.180
Obesity (≥30)	135 (9.0)	125 (92.6)	1.052 (0.995–1.111)	0.073

Percentages in the total column use the full sample; percentages uncontrolled use each BMI category as denominator. aPRs were estimated in an exploratory modified Poisson model adjusted for age category and payment category. Normal BMI (18.5–<25 kg/m²) is the reference. These categories differ deliberately from the primary 23 kg/m² action-point grouping.

Table 6. Sensitivity analyses using modified Poisson regression (n = 1,492).

Sensitivity model	Predictor	aPR	95% CI	p-value
S1a. Continuous age	Age (per 10-year increase)	0.997	0.981–1.013	0.702
	BMI ≥23 vs <23 kg/m²	1.020	0.982–1.059	0.309
	Self-pay vs JKN payment	1.069	1.025–1.115	0.002
S1b. Continuous BMI	Age ≥45 vs <45 years	1.003	0.946–1.064	0.921
	BMI (per 5 kg/m² increase)	1.013	0.994–1.033	0.166
	Self-pay vs JKN payment	1.069	1.025–1.115	0.002
S1c. Additional adjustment for sex	Age ≥45 vs <45 years	0.997	0.941–1.056	0.913
	BMI ≥23 vs <23 kg/m²	1.020	0.984–1.059	0.280
	Self-pay vs JKN payment	1.071	1.028–1.117	0.001
	Female vs male	0.972	0.938–1.008	0.127

aPR = adjusted prevalence ratio; BMI = body mass index; CI = confidence interval; JKN = Jaminan Kesehatan Nasional. All models used a Poisson distribution with log link and robust (HC0 sandwich) variance. Model S1a included continuous age per 10-year increase, BMI category, and payment category. Model S1b included age category, continuous BMI per 5 kg/m² increase, and payment category. Model S1c included age category, BMI category, payment category, and recorded sex. Reference categories were BMI <23 kg/m², age <45 years, JKN payment, and male sex, as applicable. p-values are two-sided Wald tests.

Discussion

This study documented a very high proportion of uncontrolled blood pressure, reaching 89.3% among hypertensive patients receiving care at primary healthcare facilities in Bendosari District. The observed proportion was numerically higher than the 68.1% reported among hypertensive patients in Indonesian primary care settings in Surabaya [6] and the pooled prevalence of 50.29% reported in a systematic review and meta-analysis of hypertensive patients across Sub-Saharan Africa [29]. However, these estimates are not necessarily directly comparable because study populations, antihypertensive treatment status, blood pressure measurement protocols, and definitions of blood pressure control may differ. These methodological and clinical differences should be considered when interpreting the variation across studies. Blood pressure control was classified using the values recorded at each patient's first visit during the study period, rather than longitudinal follow-up data. The analytical dataset did not specify the measurement protocol or whether the recorded values represented a single reading or an average of repeated readings. Consequently, the classification may not reflect sustained blood pressure control, and the contribution of measurement-related factors to the observed proportion could not be determined. Healthcare-

seeking behaviour and treatment adherence were not measured in this study; therefore, their contribution to the observed proportion of uncontrolled blood pressure could not be assessed. Whether these factors vary within Bendosari's peri-urban context and influence blood pressure control requires further investigation. National survey evidence likewise indicates persistent gaps in Indonesian hypertension control [7], while global pooled analyses show marked between-country heterogeneity [3], [4]. Differences in setting and denominator preclude direct ranking of these estimates. Blood pressure variability and guideline emphasis on standardised repeated measurements further support caution in interpreting a single visit's recorded values as sustained control [30], [31].

Age ≥45 versus <45 years was not significantly associated with uncontrolled blood pressure after adjustment (aPR 0.999; 95% CI 0.944–1.058; p = 0.976). Age-related vascular changes remain clinically relevant [9], and age-specific treatment and care patterns can differ between settings [10], [11]. Here, only 149 patients (10.0%) were aged <45 years, compared with 1,343 (90.0%) aged ≥45 years. We did not formally assess the effect of this imbalance on power. Dichotomisation also discards within-group information [24], especially in the broad older group. The exploratory continuous-age model did not identify a significant linear association (Table 6), but this does not establish equivalence or exclude nonlinear patterns. These findings do not demonstrate that health-system factors predominate over age-related mechanisms.

BMI ≥23 versus <23 kg/m^2 was not significantly associated with uncontrolled blood pressure after adjustment (aPR 1.022; 95% CI 0.985–1.060; p = 0.253). Biological links between adiposity and elevated blood pressure remain plausible [12], but predictors of incident hypertension [32] need not have the same associations with control among people already diagnosed. Earlier studies reported lower control among normal-BMI hypertensive US adults [13], while an Iranian study found higher adjusted odds of uncontrolled hypertension with overweight and general or abdominal obesity [14]. Conventional categories are therefore also presented in Table 5. Medication type, dose, treatment intensity, and adherence were not available in the analytical data. Treatment-related attenuation is only one possible explanation; the missing information restricted confounding adjustment and interpretation, not proof that an underlying BMI effect was concealed.

Self-pay at the index visit was associated with uncontrolled blood pressure in the bivariate analysis (p = 0.022) and the model adjusted for age and BMI categories (aPR 1.069; 95% CI 1.026–1.115; p = 0.002). The relative difference was modest, with high prevalence in both payment groups, and should not be interpreted as a causal insurance effect. Evidence from Nigeria and Ghana links insurance enrolment with adherence and control [15], while reviews and Indonesian primary-care research identify treatment continuity and adherence as relevant

issues [2], [6]. In rural Yogyakarta, government insurance and proximity to a health centre were associated with obtaining medicines from public services, but adequate medicine supply was uncommon [20]. Recent Indonesian provider research also identified medicine availability, short consultations, staffing, and patient adherence as barriers to chronic disease care [33]. Affordability, attendance, and treatment interruption are thus plausible pathways informed by external evidence, not mechanisms measured or established in Bendosari.

These results must nevertheless be interpreted with caution. A household fixed-effects study in India did not find significant improvement in the hypertension care cascade associated with insurance after accounting for household characteristics [17]. Indonesian evidence also distinguishes programme availability from effective participation and continuity. National implementation data documented expansion of Prolanis but uneven geographical uptake [18], while a literature review identified variation in activities, infrastructure, funding, and staffing [19]. A small retrospective cohort at Wates primary care reported maintained blood pressure control among regular Prolanis attendees [34], whereas a rural evaluation found deterioration in several outcomes during pandemic-related service disruption [35]. These observational findings inform plausible pathways but do not demonstrate that Prolanis explains the association in Bendosari. Although a field labelled “Prolanis” was present in the source extraction, its coding and meaning were not verified and it was not used to classify participation. JKN payment at the index visit was not treated as evidence of Prolanis participation; mediation through Prolanis was not assessed.

The adjusted prevalence ratios should be interpreted within the limited scope of the available covariates. The model included age category, BMI category, and payment category at the index visit, but did not account for potentially relevant treatment-related, clinical, and lifestyle factors. Residual confounding may therefore remain, and the estimates should not be interpreted as causal effects. Recorded sex was available and was added in an exploratory sensitivity model (Table 6); its inclusion did not materially change the payment estimate. This limited extension does not resolve treatment-related or socioeconomic confounding. Education and occupation were also present in the extraction but were not incorporated into these focused models; their availability should not be conflated with adjustment for socioeconomic circumstances.

Taken together, the observed association between payment category and blood pressure control, alongside the non-significant findings for age and BMI categories, does not establish that health-system factors are more important than individual-level factors. The relative contributions of these factors could not be determined from the present analysis. These findings support further investigation of barriers to blood pressure control across payment categories, rather than identifying a specific intervention as effective. Potential policy

options, such as expanding insurance coverage, improving medication affordability, and strengthening structured follow-up, should be considered in light of broader evidence and local needs. The present study did not evaluate these interventions and cannot establish whether they would improve blood pressure control in Bendosari.

Limitations and Suggestions

This study has several limitations that should be considered when interpreting its findings. First, the cross-sectional design permits the identification of associations but does not allow causal inference regarding the relationship between visit-level payment category and blood pressure control. Second, blood pressure control was classified using the values recorded at the index visit rather than longitudinal follow-up data. The measurement protocol and whether these values represented a single reading or an average of repeated readings were not specified in the analytical dataset. Consequently, the classification may not reflect sustained blood pressure control, and the extent of measurement-related misclassification could not be assessed. Third, the primary analysis was limited to age category, BMI category, and payment category at the index visit. Potential confounders, including antihypertensive treatment, medication adherence, duration of hypertension, comorbidities, socioeconomic characteristics, healthcare utilisation, and lifestyle factors, were not included in the adjusted model. Residual confounding by these factors may partly explain the observed association between payment category and blood pressure control. Fourth, dichotomising age at 45 years resulted in a loss of within-group information and may have obscured age-related variation, particularly because most participants were in the broad ≥45-year category. The effect of the unequal group sizes on statistical power was not formally assessed. The non-significant age finding should therefore not be interpreted as evidence that age is unrelated to blood pressure control. Finally, the findings originate from a single peri-urban district and may not be generalisable to other geographical or health-system contexts. Sensitivity analyses retained continuous age and BMI and added recorded sex, but were exploratory; they did not assess all nonlinear relationships, interactions, or omitted confounders. Individual-record robust standard errors did not account for possible correlation within facilities or villages. The reported first-visit selection and deduplication could not be independently reconstructed for every participant from the supplied analysis sheets. Finally, visit-level self-pay may include insured patients who did not use insurance, creating exposure ambiguity if interpreted as insurance ownership.

Future research should employ prospective longitudinal designs incorporating repeated or ambulatory blood pressure measurements, together with detailed data on medication regimens, adherence, comorbidities, and lifestyle behaviours, in order to characterise the determinants of blood pressure control more comprehensively. Multi-district

or multi-regional studies would also help clarify whether the association observed here between payment category and blood pressure control is consistent across different health-system settings in Indonesia.

Conclusion

Among hypertensive patients included in this study in Bendosari District, self-pay at the index visit was associated with a higher prevalence of uncontrolled blood pressure than JKN payment after adjustment for age and BMI categories (aPR = 1.069; 95% CI 1.026–1.115; p = 0.002). No statistically significant associations were observed for the age and BMI categories examined. These findings concern payment category at the recorded encounter, not verified insurance ownership, and should be interpreted cautiously because of the cross-sectional design, limited covariate adjustment, and uncertainty regarding blood pressure measurement procedures. Further research is needed to clarify the observed association and evaluate potential barriers to blood pressure control.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest.

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Authors



M. Irvan Zufar is an undergraduate medical student at the Faculty of Medicine, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia. This article is derived from his undergraduate research thesis submitted in partial fulfilment of the requirements for the medical degree. (email: J500230121@student.ums.ac.id).



Dr. dr. Yusuf Alam Romadhon, M.Kes, Sp.KKLP, FISQua, FISPH, FISCM is a specialist in family and community medicine and a senior lecturer at the Department of Family Medicine, Faculty of Medicine, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia. (email: yar245@ums.ac.id).