



Anthropometry as the Predictor of Hypertension and Proportion of Prehypertension among Posbindu's Participants in Sindangbarang City Block, Bogor City

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Abstract

This study aimed to determine the proportion of prehypertension based on sex, age group and body mass index (BMI) categories; and to analyze the association between anthropometry and participants' blood pressure. Cross-sectional design was used in this study, and a total of 180 Posbindu's participants (accessible population) enrolled in this study. The results showed that the proportion of prehypertension among male participants was not significantly different from the proportion among female participants. The proportion in men and women were 36.4% and 34.7%, respectively. Prehypertension occurred in all age groups (> 20 years). The highest proportion was found in the age group of 41-50 years (40.0%). Prehypertension occurred in all BMI categories, and the highest proportion was found in the "severe underweight" category (60%). There was a significant positive correlation between age and waist circumference with blood pressure and hypertension's categories ($p \leq 0.01$). There was a significant positive correlation between BMI, mid-upper arm circumference (MUAC) and waist-hip ratio (WHR) with blood pressure ($P \leq 0.05$). It was concluded that age, BMI, MUAC, waist circumference, hip circumference and WHR had positive correlations with participants' blood pressure.

Keywords: anthropometry; association; hypertension; predictor; prehypertension.

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1. Introduction

Hypertension is the most common degenerative disease affecting people worldwide. It is defined as a chronic increase in systemic arterial pressure above a certain threshold [1]. In adults aged 18 years or older, it is defined as a systolic blood pressure (SBP) of ≥ 140 mmHg and/or a diastolic blood pressure (DBP) of ≥ 90 mmHg, based on the mean of two or more measurements [2]. Prevalence of hypertension in Indonesia among people aged ≥ 18 years is 25.8%. West Java is the 4th province after Bangka Belitung, South Borneo and East Borneo that has a higher prevalence than the national average. The prevalence of hypertension in West Java is 29.4% [3]. These data were supported by previous study on risk factors of hypertension, which stated that the prevalence of hypertension in the age group of ≥ 15 years in Bogor Regency, West Java Province was 30.7% [4]. Furthermore, another study on 111 young adult patients (aged 18-25 years) at Cicurug Community Health Center (Puskesmas), located in Sukabumi District, West Java, concluded that 34% of them had prehypertension and 17.1% of them had hypertension [5].

Hypertension is a complex problem, which is related to unhealthy dietary pattern, low physical activity, overweight, race, genetic factors, smoking habits, sex, stress and decreased metabolic and functional abilities due to age-related aging [5-7]. It is not immediately diagnosed, because it does not show any specific symptoms. On the other hand, it is often overlooked, as evidenced by the small number of people with hypertension who perform optimal control. Only two-thirds of those detected are optimally controlled [2]. Hypertension does not occur immediately, but it usually begins with a gradual and continuous increase in blood pressure. It is preceded by prehypertension, the first stage of hypertension in which the SBP ranges from 120 to 139 mmHg and DBP ranges from 80 to 89 mmHg [8]. According to previous finding, the death rate due to age-related hypertension reached 23.1%. Therefore, various attempts are needed to detect hypertension since early stage in a cheap, easy and fast way [9].

Over the last few decades, studies concerning direct association between hypertension and anthropometric indices had been conducted, as an effort to identify the risk of hypertension. Anthropometry is an easy, economical and effective way to be used as an initial screening for hypertension [10]. Results of previous study concluded that the combination of several anthropometric indices could increase the strength of risk factors' predictors for hypertension [11]. Obesity is often considered as an immediate cause of hypertension as it is an important determinant of health, which can lead to metabolic changes including an increase in blood pressure. Some anthropometric indices that can be utilized as risk predictors of hypertension are body mass index (BMI), waist circumference (WC) and waist-hip ratio (WHR) [12-14]. Furthermore, the finding of previous study indicated that there was a significant association between mid-upper arm circumference (MUAC) in pregnant women and the incidence of preeclampsia [15]. Those findings were also supported by another study, which concluded that blood pressure was directly related to age, weight, BMI, WC and WHC [16].

From these descriptions, we conducted a study on the proportion of prehypertension and hypertension based on sex, age, BMI and the association between anthropometric indices (BMI, MUAC and WHC) and blood pressure among the participants of Posbindu (Integrated Health Service and Promotion Post) in Sindangbarang City Block, Bogor City.

2. Research Methods

2.1. Design, Location, and Time of Study

This research was an analytic observational study with cross-sectional design [17, 18]. It was conducted on four Posbindu in Village Block (RW) 4 and RW 5 in the working area of Puskesmas Sindangbarang, Sindangbarang City Block, West Bogor Sub-District, located in Bogor City, Indonesia. Data were collected from January to February 2015.

2.2. Study population and participants

The participants involved in this study were accessible population. They were the Posbindu's participants in RW 4 and RW 5 in Sindangbarang City Block. Therefore, the accessible population was part of the target population, which was confined by location and time; thus, they could be chosen as or instantly become the study participants [17]. The Posbindu's participants aged over 20 years, and they were listed as the target service of Posbindu closest to their residential area. Based on the data of Puskesmas Sindangbarang in 2014, the number of study sample covered all the participants who were administratively listed in the Puskesmas. The prevalence of hypertension in Sindangbarang was 25.41%, active visit each month was 20-30 people and the average number of participants officially registered in each Posbindu was 45 people. Study participants were chosen from four Posbindu (45 people for each Posbindu) in two RWs in Sindangbarang City Block; thus, a total of 180 people participated in this study.

2.3. Study implementation

This study began with site selection. Cluster sampling was performed to determine the sample areas (sub-district and city block), whereas probability sampling was used to determine Posbindu's location. Sampling without replacement was carried out in this study; i.e. the location that had been selected was not put back in the group for the next selection. Meanwhile, the sampling for study participants (180 people) were performed by quota sampling method [17, 18].

Measurement form and questionnaire were used when observing the participants in the field. Blood pressure, weight, height, MUAC, WC and hip circumference measurements were performed on the participants. Afterwards, interviews were conducted to collect the data on participants' sex, age, education level and occupation.

2.4. Data type and collection method

There were two types of data collected in this study; i.e. primary data that were collected through measurements and direct interview based on the questionnaire, and secondary data which were collected from Puskesmas Sindangbarang, Bogor City's Health Office.

The data collected by measurements included blood pressure, weight, height, MUAC, WC and hip circumference. The data collected through interviews were participants' sex, age, education level and

occupation. Meanwhile, the total number of Posbindu’s participants (accessible population) was obtained from the secondary data, i.e. Puskesmas Sindangbarang’s reports in 2014 on the handling of non-communicable disease.

Measurement tools used in this study were digital scale, microtoise, measuring tape and digital blood pressure monitor (OMRON HEM-7200).

The data collected by anthropometric measurements were weight (kg), height (cm), MUAC (cm), WC (cm) and hip circumference. BMI was calculated using the following formula [19]:

$$BMI (kg/m^2) = weight (kg) / [height (m)^2] \tag{1}$$

The calculation results from the above formula were then categorized based on Table 1.

Table 1: BMI categories in Indonesia [3]

Categories		BMI (kg/m ²)
Underweight	Severe underweight	< 17.0
	Mild underweight	17.0 – 18.4
Normal		18.5 – 25.0
Overweight	Mild overweight	25.1 – 27.0
	Severe overweight	> 27.0

WHR was calculated afterwards using the following formula:

$$WHR [20] = WC (cm) / hip circumference (cm) \tag{2}$$

The results were analyzed to determine metabolic syndrome’s risk levels, based on the categories presented in Table 2 and Table 3.

Table 2: Adult’s waist circumference categories

Metabolic syndrome’s risk levels	Waist circumference (cm)	
	Male	Female
Very low	< 94	< 80
Low	94-102	80-88
High	>102	>88

Table 3: Risk of metabolic complications based on adult’s waist circumference and waist-hip ratio [22]

Risk of metabolic complications	WC (cm)		WHR	
	Male	Female	Male	Female
Increased	≥ 94	≥ 80		
Substantially increased	≥ 102	≥ 88	≥ 0.90	≥ 0.85

Note: WHR >1.0 in men and > 0.85 in women indicated the abdominal fat accumulation.

Blood pressure measurements were performed by the health personnel from Puskesmas. The measurements were performed three times with 10-minute intervals. Systolic and diastolic readings were presented as mean values, and categorized based on the recommendations from the Joint National Committee 7 (JNC 7) [8] presented in Table 4.

Table 4: Categories of hypertension

Classification	SBP (mmHg)	DBP (mmHg)
Normal	<120	<80
Prehypertension	120-139	80-89
Stage 1 hypertension	140-159	90-99
Stage 2 hypertension	≥160	≥100

Note: SBP = systolic blood pressure, DBP = diastolic blood pressure.

2.5. Data processing and analysis

The data were analyzed by descriptive and inferential statistics with a 0.05 significance level. Univariate analysis was used to calculate mean, standard deviation, minimum and maximum values for numeric data; and percentages for categorical data. The data were assessed for normality by one-sample Kolmogorov-Smirnov test. The comparative test between two groups was performed using independent sample t-test for normally distributed data, and Mann-Whitney test if the data were not normally distributed. Bivariate analysis was performed to analyze the correlation between two variables by using chi-square test (contingency tables), Pearson correlation and Spearman’s rank correlation.

2.6. Ethical clearance

Ethical clearance for this study was obtained from the Ethic Committee of the Faculty of Medicine, University of Indonesia and Cipto Mangunkusumo Hospital (Number 51/UN2.F1/ETIK/1/2015) dated 19 January, 2015.

3. Results and Discussion

3.1. Participants’ characteristics

Participants' general characteristics consisting of sex, age group, education level and occupation were presented in Table 5. Based on sex, there were more female participants (81.67%) than male participants. There was no significant difference in mean age between male and female participants. Most participants were in the age group of 41-50 years; 45.5% of them were men and the rest (37.4%) were women. There was a significant difference in occupation between men and women. Most of the men (33.33%) were entrepreneurs, while most of the women (70%) were housewives and unemployed.

Table 5: Participants' general characteristics

Parameter	Men	Women	P
	(n=33)	(n=147)	
<i>Age (years)</i>	49.61 ± 8.35 ^{a#}	47.48 ± 10.37 ^{a#}	0.272
<i>Age Groups (%)</i>	(35 -74)	(23-90)	0.578†
21-30	0	2.0	
31-40	12.1	23.1	
41-50	45.5	37.4	
51-60	33.3	28.6	
> 60	9.1	8.8	
<i>Occupation (%)</i>			0.000†
Unemployed	0	85.71	
Civil servant/INAF	6.06	0.68	
Retiree	18.18	0.68	
Private employee	18.18	0.68	
Factory worker	9.1	0	
Farmer/fisherman	6.06	1.36	
Merchant	9.1	5.44	
Others (entrepreneur)	33.33	5.44	
<i>Education level</i>	4.94 ± 1.42 ^c	4.18 ± 1.41 ^d	0.022*
Never been in school	3.0	4.1	
Informal education	3.0	5.4	
Elementary school dropouts	12.1	25.2	
Elementary school graduates	12.1	24.5	
Junior high school graduates	21.2	15.0	
Senior high school graduates	45.5	25.2	
University graduates	3.0	0.7	

Notes: Values in the same column with the same superscript letters are not significantly different at $\alpha = 5\%$; # mean ± standard deviation; ^{a,b} Independent sample t-test; ^{c,d} Mann-Whitney test; † chi-square test; INAF = Indonesian National Armed Forces.

There was a significant difference in education level between men and women. Most of the men (45.45%) were senior high school graduates. Based on the education level, 25.2% of women were elementary school dropouts and 25.2% were senior high school graduates.

3.2. Participants' anthropometric characteristics and blood pressure

Anthropometric characteristics become one of the predictors of the risk factors of hypertension. Participants' anthropometric characteristics were presented in Table 6. The results showed that there were no significant differences in mean SBP and DBP between men and women. There were 42.4% of men and 36.7% of women with normal blood pressure. There were 57.6% of men and 63.2% of women who had high blood pressure. The proportion of prehypertension in men and women were 36.4% and 34.7%, respectively. The proportion of stage 1 hypertension in men and women were 12.1% and 19.0%, respectively. The proportion of stage 2 hypertension in men and women were 9.1% and 9.5%, respectively.

Men's mean BMI was significantly different from women's mean BMI, but the values were still within the normal range (18.5-25.0 kg/m²). Based on BMI categories, there were no significant differences in percentage in each category between men and women.

There were 6.0% of men and 7.5% of women who were categorized as mild and severe underweight. There were 72% of men and 51.02% of women with normal BMI. The percentages of men and women categorized as mild and severe overweight were 21.2% and 41.5%, respectively. Our findings indicated that the number of overweight women was 1.96 times more than the amount in men. Mean MUAC, WC and WHR in both sexes were not significantly different. However, based on mean WC, women (WC ≥ 80 cm) had a higher risk of hypertension than men (WC < 94 cm). Most of the men and women had WHR of > 0.90 and > 0.85, respectively; thus, both sexes were at high risk of having metabolic complications.

3.3. Proportion of Prehypertension based on age

Proportion of prehypertension and hypertension based on age were presented in Table 7. The results showed that of all the participants involved in this study, most of them (38.9%) were in the age group of 41-50 years, and only 1.7% of them were in the age group of 21-30 years. Based on the categories of hypertension, it appeared that the increase in blood pressure occurred in all age groups, with different percentages. In the age group of 21-30 years, there were 66.7% participants who had normal blood pressure, and the proportion of prehypertension was 33.3%. In the age group of 31-40 years, there were 55.3% of the participants with normal blood pressure, while the rest of them (44.7%) had high blood pressure. The proportion of prehypertension and hypertension in the group were 28.9% and 15.8%, respectively. Among the participants in the age group of 41-50 years, there were 35.7% of them who had normal blood pressure, while the rest (64.3%) had high blood pressure.

The proportion of prehypertension and hypertension in the group were 40.0% and 24.2%, respectively. In the age group of 51-60 years, 32.1% of the participants had normal blood pressure, 67.9% of them had high blood pressure, the proportion of prehypertension was 31.2% and the proportion of hypertension was 36.8%. Meanwhile, there were only 18.8% of the participants in the age group of > 60 years that had normal blood

pressure, the rest of them (81.2%) had high blood pressure. The proportion of prehypertension and hypertension in the age group of > 60 years were 37.5% and 43.8%, respectively. These findings showed that the percentage of an increase in blood pressure would increase with increasing age, either in the category of prehypertension or hypertension. Our results were consistent with the previous study, which concluded that blood pressure had a significant association with age [16].

Table 6: Anthropometric characteristics and blood pressure based on sex

Variable	Sex		P
	Men	Women	
SBP (mmHg)	126.73 ± 16.81 ^c (100-169)	130.48 ± 21.86 ^c (91-234)	0.432
DBP (mmHg)	79.67 ± 13.47 ^c (64-102)	81.09 ± 13.74 ^c (55-178)	0.710
Category of blood pressure (%)			
Normal	42.4	36.7	0.805†
Prehypertension	36.4	34.7	
Stage 1 hypertension	12.1	19.0	
Stage 2 hypertension	9.1	9.5	
BMI	22.98 ± 3.30 ^a (15.94-29.78)	24.50 ± 3.67 ^b (15.15-33.33)	0.03*
Category of BMI (%)			
Severe underweight	3.0	2.7	0.211†
Mild underweight	3.0	4.8	
Normal	72.7	51.0	
Mild overweight	12.1	17.0	
Severe overweight	9.1	24.5	
MUAC (cm)	28.06 ± 2.94 ^a (22.00-34.00)	28.88 ± 3.19 ^a	0.150
WC (cm)	80.54 ± 10.27 ^a	82.86 ± 10.22 ^a	0.241
Hip circumference (cm)	89.94 ± 8.02 ^a	93.71 ± 9.02 ^b	0.028*
WHR	0.91 ± 0.11 ^c (0.74-1.38)	0.89 ± 0.09 ^c (0.62-1.34)	0.302

Notes: Values in the same column with the same superscript letters are not significantly different at $\alpha = 5\%$; ^{a,b} Independent sample t-test; ^{c,d} Mann-Whitney test; † chi-square test.

Table 7: Proportion of hypertension based on age

Category of age groups (years)	Categories of hypertension (%)				Total number of participants (n= 180)
	Normal (n=68)	Prehypertension (n=63)	H-1 (n=32)	H-2 (n=17)	
21-30	66.7	33.3	0	0	1.7 (n=3)
31-40	55.3	28.9	7.9	7.9	21.1 n=38)
41-50	35.7	40.0	17.1	7.1	38.9 (n=70)
51-60	32.1	32.1	26.4	9.4	29.4 (n=53)
> 60	18.8	37.5	18.8	25.0	8.9 (n=16)

Note: H-1 = Stage 1 hypertension, H-2 = Stage 2 hypertension.

3.4. Proportion of Prehypertension based on BMI

Hypertension is often associated with obesity; thus, BMI can be used as an initial indicator to detect hypertension. Previous research concluded that overweight and obesity were the risk factors of prehypertension and hypertension in men and women [23]. The analysis based on BMI category showed that 7.2% of the participants were underweight, 55% of them were classified as normal and 37.8% of them were overweight and obese. The proportion of hypertension based on BMI categories were presented in Table 8. The results showed that the 40% of the participants categorized as severe underweight had normal blood pressure, and 60% of them had prehypertension. In participants categorized as mild underweight, the proportion of the ones with normal blood pressure, prehypertension and hypertension were 25%, 25% and 50%, respectively. There were 39.4% of participants with normal BMI who had normal blood pressure, while the rest of them had prehypertension (37.4%) and hypertension (23.3%). In mild-overweight participants, there were 41.4% of them who had normal blood pressure, while the rest had prehypertension (27.6%) and hypertension (31%). Meanwhile, the proportion of normal blood pressure, prehypertension and hypertension among severe-overweight participants were 33% in each category.

This study indicated that high blood pressure was found in all BMI categories because blood pressure was not only affected by BMI, but also by other factors (age, dietary pattern and physical activity). This finding had also been explained by other researchers, who stated that hypertension was a complex problem [6]. It was related to unhealthy dietary pattern, lack of physical activity, overweight, race, genetic factors, smoking habits, sex, stress and the decreased metabolic and functional abilities due to age-related aging.

3.5. Correlations of several hypertension's risk factors with systolic and diastolic blood pressure

The risk factors for hypertension that have been identified were classified into two groups; i.e. unmodifiable risk factors (sex, age, genetics and race), and modifiable risk factors such as overweight, high sodium intake, low potassium intake, alcohol consumption, smoking habits, low physical activity and stress [7,24,25]. The analysis results of the relationship between risk factors for hypertension and blood pressure were presented in Table 9.

The results showed that sex was not significantly associated with SBP and DBP ($P > 0.05$). Although sex did not affect SBP and DBP, but mean blood pressure (SBP and DBP) and the number of women with hypertension tended to be higher than men. The previous study in 2015 revealed that the prevalence of hypertension in men decreased with increasing age (P -trend < 0.001). Conversely, the prevalence of hypertension in women increased with increasing age (P -trend < 0.001) [26]. These results were also in line with the findings of another study [27], which concluded that prevalence of hypertension in premenopausal women was lower than the one in men. However, the prevalence in postmenopausal women was higher than the one in men. This happened due to the decreased estrogen, increased oxidative stress, endothelial cell dysfunction, as well as the increased activation of renin-angiotensin system and sympathetic nervous system.

Table 8: Proportion of hypertension based on BMI

BMI categories	Categories of hypertension (%)				Total number of participants	
	Normal	Prehypertension	H-1	H-2	n	%
Severe underweight	40.0	60.0	0.0	0.0	5	2.8
Mild underweight	25.0	25.0	25.0	25.0	8	4.4
Normal	39.4	37.4	15.2	8.1	99	55
Mild overweight	41.4	27.6	13.8	17.2	29	16.1
Severe overweight	33.3	33.3	28.2	5.1	39	21.7

Table 9: Association between risk factors for hypertension and SBP or DBP

Measurement parameters	SBP		DBP		Categories of hypertension	
	Correlation coefficient	P	Correlation coefficient	P	Correlation coefficient	P
Sex	0.049	0.571 ^a	-0.028	0.711	0.058	0.442
Age	0.296	0.000**	0.021	0.779	0.266	0.000**
BMI	0.110	0.140	0.173	0.020*	0.056	0.452
MUAC	0.143	0.056	0.159	0.033*	0.095	0.202
WC	0.236	0.001**	0.193	0.009**	0.256	0.001**
Hip circumference	0.152	0.041*	0.136	0.069	0.118	0.115
WHR	0.131	0.079	0.133	0.074	0.158	0.035*

Notes: ^aChi-square test, $P < 0.05$, Pearson correlation; *correlation is significant at the 0.05 significance level (2-tailed); **correlation is significant at the 0.01 significance level (2-tailed); † Spearman rho

Our findings also showed that there was a strong significant positive association between age and participants'

SBP ($P \leq 0.01$), but no significant association found between age and DBP ($P > 0.05$). BMI had no significant association with SBP ($P > 0.05$), but it had a significant association with DBP ($P \leq 0.05$).

The association between DBP and BMI had also been explained in WHO report in 2000, which revealed that an increase in DBP occurred with increasing BMI, and the prevalence of hypertension would increase 2.9 times in overweight subjects than in subjects with normal weight [19]. MUAC had no significant association with SBP ($P > 0.05$), but it had a significant association with DBP ($P \leq 0.05$). WC had a strong significant association with SBP ($P \leq 0.01$) and DBP ($P \leq 0.01$). Hip circumference was significantly associated with SBP ($P \leq 0.05$), in contrast to its association with DBP ($P > 0.05$). WHR had no significant association with SBP and DBP ($P > 0.05$).

The results of the overall analyses showed that blood pressure was not significantly associated with sex, but significantly associated with age, BMI, MUAC, WC and hip circumference. Our findings were consistent with the results from previous study, which concluded that blood pressure was significantly related to age, body weight, BMI, WC and WHR [16]. According to other researchers, the results of multivariate analysis showed that an increase in age could increase the risk of hypertension by 2.3-fold (OR = 2.3; 95% CI: 1.84-2.87), and an increase in BMI could increase the risk of prehypertension by 4.67-fold (OR = 4.67; 95% CI: 3.35-6.51) [29]. The increasing age might increase the risk of hypertension due to the increased pressure in blood vessels that were no longer able to stretch [30]. An increase in age is also accompanied by various physical changes, including the changes in the amount, composition and structure of endothelial cells, the increase in reactive oxygen species (ROS) and inflammation. Previous study revealed that the increase in age, BMI and the incidence of central obesity were significantly related to the prevalence of prehypertension and hypertension [31]. Previous researchers stated that there was a strong correlation between BMI and hypertension; thus, obesity and overweight become one of the risk factors that get a serious attention nowadays [23]. This statement was supported by other researchers, who stated that there was a significant positive association between BMI and blood pressure [32]. The results of previous study in Manado, Indonesia also concluded that there was a significant association between BMI and blood pressure in patients with hypertension [33]. A research held in India revealed that BMI and WHR had strong correlations with SBP and DBP [34]. The study in South Africa suggested that WC had a significant correlation with blood pressure, prehypertension and hypertension in women, but no correlation found in men [35]. Partial correlation analyses on men and women indicated that age, BMI and WHR had independent effects on hypertension (DBP) [36]. WHR is the second important risk factors after BMI. It has a significant positive correlation with hypertension when compared to other anthropometric parameters. These findings are supported by the previous study in Tanzania [37]. A research among Saudi adult population suggested that WHR was the most important predictor for blood pressure levels and hypertension [38]. Anthropometric indices that can be used as predictors of hypertension differ for both sexes. Some would recommend WC to be used for predicting high blood pressure [39]. According to some researchers, WHR was a slightly better predictor in men, while WC was better used in women rather than other measurements. Therefore, anthropometric measurements were useful, as the first step to predict the risk of hypertension. Our study had some limitations as follows: 1) this was a cross sectional study conducted in the limited area coverage with limited number of participants; 2) the proportion of women in this study was higher than men.

4. Conclusion

The proportion of prehypertension in men was not significantly different from the proportion in women. Prehypertension occurred in all age group (> 20 years), and the highest proportion was found in the age group of 41-50 years. It was found in all BMI categories, in which the highest proportion was found in severe-underweight participants. Age and WC had strong significant positive correlations with blood pressure and categories of hypertension ($P \leq 0.01$). An increase in age was accompanied by an increase in participants' blood pressure; thus, they were at high risk of having hypertension. BMI, MUAC, WC and WHR had positive correlations with blood pressure. It meant that the higher the BMI, MUAC, WC and WHR values, the higher the participants' blood pressure; thus, increasing the risk of having hypertension.

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