BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2022-065056
Article Type:	Original research
Date Submitted by the Author:	02-Jun-2022
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Keywords:	Hypertension < CARDIOLOGY, EPIDEMIOLOGY, Community child health < PAEDIATRICS, PUBLIC HEALTH

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Prevalence and Associated Factors for Prehypertension and Hypertension among Indonesian Adolescents: A cross-sectional community survey

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Keywords: prehypertension, hypertension, adolescents, nutritional status, lipid profile

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Word count - excluding title page, Contributorship statement, Competing interests , Funding, Data sharing statement, references, figures and tables: 5332

Prevalence and Associated Factors for Prehypertension and Hypertension among Indonesian Adolescents: A cross-sectional community survey

ABSTRACT

Objective: To determine the prevalence and factors associated with the incidence of prehypertension and hypertension in Indonesian adolescents.

Design: National cross-sectional study

Setting: This study was conducted in all the provinces in Indonesia.

Participants: The population in this study were all household members in Basic Health Research 2013 aged 15-19 years. The sample is all members of the 2013 Riskesdas household aged 15-19 years with the criteria of not having physical and mental disabilities, and having complete data. The number of samples analyzed was 2735, comprising of men (n = 1319) and women (n = 1416).

Main Outcome: Dependent variables are prehypertension and hypertension in adolescents based on blood pressure measurements.

Results: The results of the analysis showed that the prevalence of pre-hypertension in adolescents was 16.8% and hypertension was 2.6%. In all adolescents, the risk factors for prehypertension were female (RRR 1.48; 95% CI 1.10-1.97), 18 years old (RRR 14.64; 95% CI 9.39-22.80), and 19 years old (RRR 19.89; 95% CI 12.41-31.88), and obese (RRR 2.16; 95% CI 1.02-4.58). Risk factors for hypertension in all adolescents include 18 years old (RRR 3.06; 95% CI 1.28-7.34) and 19 years (RRR 3.25; 95% CI 1.25-8.41) and obesity (RRR 5.69; 95% CI 2.20-14.8). In adolescent girls, the chance of developing prehypertension increases with increasing age and Low-Density Lipoprotein (LDL) cholesterol levels. Several risk factors for hypertension in adolescent boys are age, central obesity, and LDL cholesterol levels.

Conclusion: This study shows that the trend of prehypertension in adolescents has appeared, besides hypertension. There are distinct patterns of factors that influence it in adolescent girls and boys, so that it can sharpen the steps of the program that have been prepared.

Keywords: prehypertension, hypertension, adolescents, nutritional status, lipid profile

Strengths and limitations of this study

- The data on prehypertension and hypertension in adolescents that we present are enriching the evidence base of NCD at a young which is rarely raised in our country.
- In this study, hypertension status was obtained based on measurement results not only from the respondent's acknowledgment.
- Several independent variables are also based on measurement results, such as BMI, abdominal circumference, lipid levels.
- The cross-sectional design of the study does not show a causal relationship.
- Several important independent variables that were not involved in the analysis: parental history of hypertension, food consumption.

INTRODUCTION

Non-communicable diseases (NCDs) are the leading cause of death globally, with 41 million people each year, equivalent to 71% of all deaths [1]. Indonesia's latest condition in 2020 is that NCDs accounted for 73% of total deaths (1,365,000 deaths because of NCDs), and 26% of premature deaths because of NCDs [2]. Globally, the number one metabolic risk factor for NCD death is elevated blood pressure, which causes 19% of global deaths, followed by overweight/obesity, and elevated blood glucose [1].

Hypertension is often associated with a disease in adults and the elderly, but the trend of hypertension at a young age also cannot be underestimated. The results of monitoring through a national survey in Indonesia in 2007 reported that hypertension at 15-17 years reached a quarter (8.4%) of the prevalence at 18 years and over (31.7%) [3]. The risk factors for hypertension in Indonesian adolescents have also increased. We can see this from the monitoring of the Global School-based Student Health Survey (GSHS) in 2007-2015, the obesity indicator increased from 1.3% to 4.9%, overweight from 5.8% to 8. 4%. The fruit consumption indicator decreased from 69.6% to 63.9%. Vegetable consumption also decreased from 83.3% to 82.15%. And indicators of daily physical activity of at least 60 minutes per day also decreased from 16.5% to 12.23% [4,5]. Another condition that also needs to be watched out for is a quarter (25.9%) of adolescents aged 13-18 years consuming >2000mg daily sodium [6]. These worsening indicators of hypertension risk factors are alarming for an increase in hypertension in adolescents. We can already see the impact of hypertension on adolescents from the damage to several organs that have been shown to occur in adolescents with hypertension: left ventricular hypertrophy, retinopathy, and microalbuminuria [7]. Not only the problem of hypertension is a concern, but the condition of prehypertension also cannot be ruled out. In a meta-analysis of cohort studies, patients with prehypertension have a greater risk of having a stroke, myocardial infarction (MI), and cardiovascular (CVD) [8]. Data on prehypertension at 40 years of age and older in Indonesia in the year 2014 is estimated at 32.5% [9].

A systematic review of 50 cohort studies from the United States, Europe, Asia, Australia, Canada, Israel, and New Zealand showed that increased blood pressure in childhood is a predictor of adult hypertension, and this condition requires early intervention [10]. Boys and girls, with the influence of puberty, have different blood pressure patterns [11]. And the pattern of hypertension in boys and girls may have different paths to adult hypertension [10].

By 2045, nearly 60 percent of Indonesia's population is under the age of 30. We can say it, Indonesia will get a demographic bonus. This means that the population of productive and educated age will be more than in the previous period. This demographic bonus will be a gift, but if it is not used properly, it will become a disaster. If not, investment in the health of young people is not well maintained, then this population of productive age can become a liability, not an asset [12].

Given the enormous potential of the adolescent group and the risk of developing hypertension, we wanted to know the magnitude of the problem and the factors associated with the incidence of prehypertension and hypertension in Indonesian adolescents. So that we can use it more in sharpening hypertension control programs in the adolescent group.

METHODS

Study Design and Population

This study uses secondary data from Indonesian Basic Health Research 2013 collected from 33 provinces. The study design was cross-sectional. The population in this study were all household members in Basic Health Research 2013 aged 15-19 years. While the sample is all members of the 2013 Basic Health Research household aged 15-19 years with the criteria of not having physical and mental disabilities, and having complete data. The number of samples at the beginning of the analysis was 2966. After correction of the outliers of height, weight, and several variables, as well as the completeness of the data, the number of samples analyzed was 2735. This number of samples still met the calculation results of the minimum sample [13].

Measurements

The data collected in this study include data on demographic characteristics, health conditions of non-communicable diseases, and health-related behavior. Data was collected through face-to-face interviews by enumerators with trained health backgrounds, who visited respondents from house to house. The respondent's health condition was also measured using measurement methods, including measurements of blood pressure, weight, height, and abdominal circumference which were also carried out by enumerators at the respondent's home. The data collected was recorded on a paper questionnaire and then entered into the computer. The process of collecting data in the field is monitored by a person in charge of the field at the district/city level, to ensure data quality.

Blood pressure measurements were carried out on respondents aged 15 years and over. Measurement of blood pressure using a digital tensimeter/digital tensimeter Omron brand type IA1 and measurements are made on the left arm. Each respondent is measured for tension at least 2 times. If the results of the second measurement differ by 10 mmHg compared to the first measurement, a third measurement is carried out. The two-measurement data with the smallest difference from the last measurement are calculated on average as the result of measuring blood pressure [14].

Measurements of height and weight were carried out for all respondents, all age groups, and genders. Height measurements were not carried out for respondents who were seriously ill, had limitations in following the measurement procedure, and were pregnant women. This measurement procedure is carried out by two enumerators with one task as measuring and the other as recording the measurement results. The weight measurement tool uses a digital scale from the Fesco brand with an accuracy of 0.1 kg. Every day the instrument calibration is carried out before collecting data (Riskesdas 2013 Report). Measurement of height was measured with a "Multifunctional" height measuring instrument with a measuring capacity of two meters and an accuracy of 0.1 cm [14].

Measurement of abdominal circumference using a Medline tape measure. All anthropometric measurements were carried out using measurement guidelines [14]. Measurements are made by sticking a measuring tape directly on the skin, with no clothes sticking to the stomach. The measuring point is determined by determining the midpoint between the edge of the lowest rib and the endpoint of the hip bone arch. Measurement by drawing a parallel/horizontal line around the waist and abdomen.

The biomedical examination of the respondents was carried out after signing the informed consent. In clinical chemistry examination, it was carried out specifically on specimens from respondents aged 15 years. The biomedical examination was carried out based on the results of taking venous blood (10 cc) and then the sample was analyzed at the Research and Development Agency Laboratory. Clinical chemistry examination was carried out automatically using Cobas(R) Roche (Chol2, Crep2, HDLC3, LDL_C, Trigl) with colorimetric enzymatic principles for several tests, namely total cholesterol, HDL, direct LDL, triglycerides, and creatinine [15].

Measurement of physical activity variables is based on a composite calculation of the type and duration of activity (days per week and minutes per day) including the exercise performed. Data were collected by asking about physical activity habits/physical activities related to work and leisure time which included heavy, moderate, and sedentary physical activity with a duration of more than 10 minutes continuously. The number of active days in the week and the duration of the activity will be converted to MET. Heavy activity or heavy exercise weighs 8 times, moderate activity or moderate exercise weighs 4 times, and light activity weighs 2 times. Subjects are categorized as less active if they have a total activity of less than 600 MET (metabolic equivalent) in one week [16].

Consumption of fruit and vegetables is assessed by calculating the number of days of consumption in a week and the number of servings of average consumption in a day. After that, the category is categorized as 'enough' if you eat vegetables and/or fruit if you eat vegetables and/or fruit at least 5 portions per day for 7 days a week. Categorized as 'less' if the consumption of vegetables and/or fruit is less than the above provisions [14].

Outcome Variable

The main outcomes in this study were prehypertension and hypertension in adolescents. The results of measurements of systolic and diastolic blood pressure in adolescents 15-17 years are categorized as prehypertension is defined as average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile. as average SBP and/or DBP that is greater than or equal to the 95th percentile for sex, age, and height on three or more occasions [17]. At the age of 18-19 years, prehypertension if the systolic limit is 120-139 mmHg and/or diastolic 80-89 mmHg. Hypertension at the age of 18-19 years is determined by systolic limit >= 140 mmHg and/or diastolic >= 90 mmHg (according to JNC VII). [18].

Independent variables

The independent variables consist of individual characteristics, gender, marital status, age, occupation, education level, residency, smoking behavior, physical activity, fruit and vegetable eating habits, fatty/fried food habits, BMI, and lipid profile. Gender (male and female), age group (15-17 years and 18-19 years), highest education level completed with proof of diploma (less than elementary, junior high, and high school), marital status (unmarried and married), employment status (not working, school, working and looking for work), residency (urban and rural), physical activity grouped (enough, and less), smoking (never smoked, ever smoked, and currently smokes), consumption habits vegetables (enough, lacking), and consumption habits of fatty/fried foods are grouped according to the frequency of consumption (rare 3 times/month, Often 2-6 times/week, daily ≥ 1 time/day).

Metabolic syndrome variables consist of total cholesterol, LDL, TG, HDL, hypertension, and DM. Total cholesterol (K-total) was grouped 1. normal (<200 mg/dL) and 2. high (≥200 mg/dL). LDL cholesterol (K-LDL) levels, consist of: 1. normal (<100 mg/dL) and 2. high (≥100 mg/dL). HDL (K-HDL) cholesterol levels were grouped 1. normal 40 mg/dL (men), 50 mg/dL (women) and 2. low <40 mg/dL (men), <50 mg/dL dL (female). Meanwhile, triglyceride (TG) levels were grouped 1. normal (<150 mg/dL) and 2. high (≥150 mg/dL) [19,20].

Assessment of nutritional status was carried out using 2 criteria, where the age group was younger or equal to 18 years using the BMI-for-age z-score (BAZ) indicator and for those aged 19 years using the Body Mass Index calculation. To assess nutritional status using the BAZ indicator, the weight and height figures of each subject were converted into standardized values (z-score) using 2005 WHO child anthropometry reference. Furthermore, based on the Z Score value of each of these indicators, nutritional status was determined with limits. as follows: thin (BAZ<-2 SD), good/normal (BAZ≥-2 SD - -2 SD), obese (BAZ>2 SD). Analysis of the conversion of weight and height into BMI (nutritional status) using the formula of weight (meters) divided by height squared (m^2) then categorized according to the BMI category according to WHO (2000), namely: underweight (BMI<18.5 kg/m2), good/normoweight (BMI= 18,5-24,9 kg/m2), overweight (BMI= 25,0-29,0 Kg/m^2) dan obese (BMI≥30,0 kg/m^2) [21].

Central obesity was assessed using the abdominal circumference of adolescents aged 18 years or younger using the P90 cut-off by sex and age for children and adolescents 6-18 years [22] and at age 19 years using the International Diabetes Federation and the Indonesian Ministry of Health recommended cut-off for adult (for women >80 cm and men > 90 cm) [23].

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Data analysis

Data analysis was carried out in stages, namely univariate, bivariate, and multivariate analysis. Univariate analysis is intended to determine the distribution of the value of each variable. While the bivariate analysis aims to determine the relationship of each risk factor variable with hypertension by using the Chi-square test and logistic regression. Furthermore, multivariate analysis was carried out to determine the relationship of risk factor variables together with hypertension in adolescents using multivariate logistic regression analysis of risk factor models. Multivariate analysis was performed using logistic regression analysis. Variables with a significant value of $p<0.05$ were selected, then included in the candidate multivariate model. All analyzes used statistical software.

RESULTS

Sociodemographic characteristics

Table 1. shows a description of the characteristics of the girls and boys who participated in this study. Of the total 2,725 individuals, 1,416 were female and 1,319 were male. In general, the majority of respondents were 17 years old (23%), unmarried (94.3%), junior-high-school graduates (48.9%), and current work status as students/schooling (49.5%).

Regarding the location of residence, 52.3% were in rural areas. Some characteristics which were related to health, the majority of adolescents were underweight (80.6%), did not have central obesity (89.4%), had an insufficient level of physical activity (84.1%), and had never smoked (76.3%). When viewed the characteristics of food consumption, most of the respondents admitted that they often consumed fat (50.4%) and consumed less fruit and vegetables (98.3%). Based on lipid profile measurement, it was found that the percentage of adolescents with high total cholesterol levels (>200 mg/dl) was 10.4%, high LDL cholesterol levels (>=130 mg/dL) reached 13.8%, had high triglyceride levels (>= 150 g/dL) by 12.2% and with low HDL cholesterol levels (<40 mg/dL) reached 24.6%. In this study, the proportion of students with hypertension was 2.6% and pre-hypertension was 16.8%.

Sociodemographic and health characteristics differed between boys and girls significantly for marital status, education level, working status, nutritional status, central obesity, physical activity, smoking behavior, total cholesterol level, LDL cholesterol level, HDL cholesterol level, and hypertension pattern. There was a difference in marital status whereas married status is more common in girls. From the characteristics of working status, boys work more than girls. In addition, girls have a higher level of education than boys. Differences based on nutritional status found that girls were more overweight, obese, and had central obesity than boys. Girls were less physically active than boys. Boys were more likely than girls to engage in smoking behavior. High levels of total cholesterol and LDL cholesterol were more common in girls. While low HDL levels were more common in boys than girls. Pre-hypertension was higher in boys than girls, but the prevalence of hypertension did not differ between girls and boys.

Table 1. Sociodemographic and health-related characteristics of 2,735 participants in the 2013 Riskesdas, in total and by gender

Characteristics	Girls		Boys		p-value	Total	
	n=1,416	%	n= 1,319	%		n=2,735	%

Age (years)					0.736		
15	321	22.7	298	22.6		619	22.6
16	270	19.1	260	19.7		530	19.4
17	340	24	289	21.9		629	23
18	273	19.3	270	20.5		543	19.9
19	212	15	202	15.3		414	15.1
Marital status					<0.001		
Not married yet	1,282	90.5	1,296	98.3		2,578	94.3
Married	134	9.5	23	1.7		157	5.7
Level of education completed					0.023		
Primary school or no schooling	353	24.9	372	28.2		725	26.5
Junior Highschool	686	48.5	650	49.3		1,336	48.9
Senior Highschool	377	26.6	297	22.5		674	24.6
Working status					<0.001		
Not working	473	33.4	364	27.6		837	30.6
Student	735	51.9	620	47		1,355	49.5
Currently working	163	11.5	266	20.2		429	15.7
Still look for job	45	3.2	69	5.2		114	4.2
Residence					0.826		
Rural	738	52.1	693	52.5		1,431	52.3
Urban	678	47.9	626	47.5		1,304	47.7
Nutritional status					<0.001		
Normoweight	114	8.1	192	14.6		306	11.2
Underweight	1,174	82.9	1,031	78.2		2,205	80.6
Overweight	98	6.9	72	5.5		170	6.2
Obese	30	2.1	24	1.8		54	2
Central obesity					<0.001		
No	1,207	85.2	1,239	93.9		2,446	89.4
Yes	209	14.8	80	6.1		289	10.6
Physically active					<0.001		
Yes	129	9.1	307	23.3		436	15.9
No	1,287	90.9	1,012	76.7		2,299	84.1
Smoking behavior					<0.001		
Never smoked	1,405	99.2	682	51.7		2,087	76.3
Ever smoked	6	0.4	71	5.4		77	2.8
Currently smoking	5	0.4	566	42.9		571	20.9
Fat consumption					0.65		
Rare	134	9.5	114	8.6		248	9.1
Frequent	703	49.7	674	51.1		1,377	50.4
Everyday	579	40.9	531	40.3		1,110	40.6
Fruits and vegetables consumption					0.116		
Sufficient	19	1.3	28	2.1		47	1.7
Insufficient	1,397	98.7	1,291	97.9		2,688	98.3
Level of total cholesterol					<0.001		
Normal (<200 mg/dl)	1,206	85.2	1,245	94.4		2,451	89.6
High (>200 mg/dl)	210	14.8	74	5.6		284	10.4
Level of LDL cholesterol					<0.001		
Normal (<130 mg/dl)	1,150	81.2	1,209	91.7		2,359	86.3
High (>=130 mg/dl)	266	18.8	110	8.3		376	13.8
Level of triglycerides					0.354		
Normal (<150 mg/dl)	1,251	88.4	1,150	87.2		2401	87.8
High (>=150 mg/dl)	165	11.7	169	12.8		334	12.2
Level of HDL cholesterol					<0.001		
Normal (>=40 mg/dl)	1,191	84.1	870	66		2,061	75.4
Low (<40 mg/dl)	225	15.9	449	34		674	24.6
Hypertension					0.02		
Normotensive	1,169	82.6	1,036	78.5		2,205	80.6
Pre-hypertensive	210	14.8	248	18.8		458	16.8
Hypertensive	37	2.6	35	2.7		72	2.6

Bivariate analyses

The results of the bivariate analysis were presented in Table 2. In general, several risk factors for hypertension and pre-hypertension in adolescents include age, marital status, level of education completed, working status, smoking behavior, total cholesterol levels, and LDL cholesterol levels. Meanwhile, when viewed by gender, the risk factors associated with hypertension and pre-hypertension in girls include age, marital status, education level, working status, and LDL cholesterol levels. In boys, the risk factors associated with hypertension and pre-hypertension were age, education level, working status, nutritional status, central obesity, smoking behavior, total cholesterol levels, and LDL cholesterol levels.

Risk factors associated with Prehypertension and Hypertension among adolescents

Multivariate analysis showed the risk factors for pre-hypertension in all adolescents and by gender (Table 3). In all adolescents, the risk factors for pre-hypertension were female (RRR 1.48 95% CI 1.10-197), at the age of 18 years old (RRR 14.64 95% CI 9.39-22.80), and 19 years old (RRR 19.89 95% CI 12.41-31.88), and obese (RRR 2.16 95% CI 1.02-4.58). Whereas in girls, the chance of developing pre-hypertension increases with increasing age and LDL cholesterol levels. At the age of 18 years and 19 years, the risk for developing pre-hypertension was 15.33 times (95% CI 8.16-28.83) and 12.21 times (95% CI 6.30-23.65) higher when compared to the age of 15 years. Adolescent girls who have high LDL cholesterol levels (>=130 mg/dL) had a relative risk of pre-hypertension 1.48 times (95% CI 1.01-2.16) higher than those with normal LDL cholesterol levels. Data analysis on boys showed that age was also a risk factor for pre-hypertension where at the age of 18 years and 19 years old the risk was 14.45 times (95% CI 7.79-26.80) and 33.42 times (95% CI 17.17-65.05) higher if compared to 15 years of age. In addition, there were also found protective factors against pre-hypertension, namely the age of 16 years (RRR 0.21 95% CI 0.006-0.72) and underweight (RRR 0.54 95% CI 0.33-0.68).

Multivariate analysis showed the risk factors for hypertension in all adolescents and by gender (Table 4). Significant risk factors for hypertension in all adolescents include at the age of 18 years old (RRR 3.06 95% CI 1.28-7.34) and 19 years (RRR 3.25 95% CI 1.25-8.41) and obesity (RRR 5.69 95% CI 2.20-14.8). Some factors show a lower risk of pre-hypertension, namely high school graduates (RRR 0.70 95% CI 0.51-0.98) and underweight (RRR 0.66 95% CI 0.47-0.95). Meanwhile, several risk factors for hypertension in boys were age, central obesity, and LDL cholesterol levels. Older age showed a higher risk of developing hypertension, where at the age of 18 years the risk was 4.92 times (95% CI 1.15-21.00) and at 19 years the risk was 13.06 times (2.95-57.75) higher than at the age of 15 years. Boys who were centrally obese had 5.15 times (95% CI 1.36-1947) higher risk of hypertension than those who were not centrally obese. In addition, boys with a high level of LDL cholesterol (>=130 mg/dL) had a 3.15 times (95% CI 1.31-7.56) higher risk than those with normal LDL cholesterol levels for hypertension.

Table 2.
Factors Associated to Hypertension and Prehypertension in Adolescents based on Riskesdas 2013, according to sociodemographic and health characteristics

Characteristics	Girls				Boys				Overall			
	Normal n (%)	Pre-hypertension n (%)	Hypertension n (%)	p-value	Normal n (%)	Pre-hypertension n (%)	Hypertension n (%)	p-value	Normal n (%)	Pre-hypertension n (%)	Hypertension n (%)	p-value
Age (years)				<0.001				<0.001				<0.001
15	301 (93.8)	13 (4.0)	7 (2.2)		278 (93.3)	17 (5.7)	3 (1.0)		579 (93.5)	30 (4.8)	10 (1.6)	
16	248 (91.8)	17 (6.3)	5 (1.8)		252 (96.9)	3 (1.2)	5 (1.9)		500 (94.3)	20 (3.8)	10 (1.9)	
17	311 (91.5)	19 (5.6)	10 (2.9)		270 (93.4)	13 (4.5)	6 (2.1)		581 (92.4)	32 (5.1)	16 (2.5)	
18	165 (60.4)	97 (35.5)	11 (4.0)		155 (57.4)	105 (38.9)	10 (3.7)		320 (58.9)	202 (37.2)	21 (3.9)	
19	144 (67.9)	64 (30.2)	4 (1.9)		81 (40.1)	110 (54.5)	11 (5.4)		225 (54.4)	174 (42.0)	15 (3.6)	
Marital status				<0.001				0.562				<0.001
Not married yet	1.077 (84.0)	171 (13.3)	34 (2.6)		1.020 (78.7)	242 (18.7)	34 (2.6)		2.097 (81.3)	413 (16.0)	68 (2.6)	
Married	92 (68.7)	39 (29.1)	3 (2.2)		16 (69.6)	6 (26.1)	1 (4.4)		108 (68.8)	45 (28.7)	4 (2.6)	
Level of education completed				<0.001				<0.001				<0.001
Primary school or no schooling	300 (85.0)	46 (13.0)	7 (2.0)		306 (82.3)	59 (15.9)	7 (1.9)		606 (83.6)	105 (14.5)	14 (1.9)	
Junior Highschool	587 (85.6)	83 (12.1)	16 (2.3)		549 (84.5)	86 (13.2)	15 (2.3)		1.136 (85.0)	169 (12.7)	31 (2.3)	
Senior Highschool	282 (74.8)	81 (21.5)	14 (3.7)		181 (60.9)	103 (34.7)	13 (4.4)		463 (68.7)	184 (27.3)	27 (4.0)	
Working status				0.003				<0.001				<0.001
Not working	376 (79.5)	84 (17.8)	13 (2.8)		289 (79.4)	67 (18.4)	8 (2.2)		665 (79.5)	151 (18.0)	21 (2.5)	
Student	634 (86.3)	84 (11.4)	17 (2.3)		527 (85.0)	81 (13.1)	12 (1.9)		1.161 (85.7)	165 (12.2)	29 (2.1)	
Currently working	129 (79.1)	29 (17.8)	5 (3.1)		177 (66.5)	77 (29.0)	12 (4.5)		306 (71.3)	106 (24.7)	17 (4.0)	
Still look for job	30 (66.7)	13 (28.9)	2 (4.4)		43 (62.3)	23 (33.3)	3 (4.4)		73 (64.0)	36 (31.6)	5 (4.4)	
Residence				0.416				0.193				0.395
Rural	602 (81.6)	118 (16.0)	18 (2.4)		555 (80.1)	124 (17.9)	14 (2.0)		1.157 (80.8)	242 (16.9)	32 (2.2)	
Urban	567 (83.6)	92 (13.6)	19 (2.8)		481 (76.8)	124 (19.8)	21 (3.4)		1.048 (80.4)	216 (16.6)	40 (3.1)	
Nutritional status				0.129				0.015				0.001
Normoweight	978 (83.3)	168 (14.3)	28 (2.4)		812 (78.7)	190 (18.4)	29 (2.8)		1.790 (81.2)	358 (16.2)	57 (2.6)	
Underweight	92 (80.7)	20 (17.5)	2 (1.8)		154 (80.2)	36 (18.8)	2 (1.0)		246 (80.4)	56 (18.3)	4 (1.3)	
Overweight	78 (79.6)	16 (16.3)	4 (4.1)		57 (79.2)	14 (19.4)	1 (1.4)		135 (79.4)	30 (17.7)	5 (2.9)	
Obese	21 (70.0)	6 (20.0)	3 (10.0)		13 (54.2)	8 (33.3)	3 (12.5)		34 (63.0)	14 (25.9)	6 (11.1)	
Central obesity				0.417				0.018				0.084
No	1.003 (83.1)	174 (14.4)	30 (2.5)		58 (72.5)	16 (20.0)	6 (7.5)		1.981 (81.0)	406 (16.6)	59 (2.4)	
Yes	166 (79.4)	36 (17.2)	7 (3.4)		978 (78.9)	232 (18.7)	29 (2.3)		224 (77.5)	52 (18.0)	13 (4.5)	
Physically active				0.665				0.217				0.157
Yes	106 (82.2)	21 (16.3)	2 (1.6)		231 (75.2)	65 (21.2)	11 (3.6)		337 (77.3)	86 (19.7)	13 (3.0)	
No	1.063 (82.6)	189 (14.7)	35 (2.7)		805 (79.5)	183(18.1)	24 (2.4)		1.868 (81.2)	372 (16.2)	59 (2.6)	
Smoking behavior				0.363				<0.001				<0.001

Never smoked	1.162 (82.7)	206 (14.7)	37 (2.6)		563 (82.5)	103 (15.1)	16 (2.4)		1.725 (82.7)	309 (14.8)	53 (2.5)	
Ever smoked	4 (66.7)	2 (33.3)	0 (0.0)		61 (85.9)	9 (12.7)	1 (1.4)		65 (84.4)	11 (14.3)	1 (1.3)	
Currently smoking	3 (60.0)	2 (40.0)	0 (0.0)		412 (72.8)	136 (24.0)	18 (3.2)		415 (72.7)	138 (24.2)	18 (3.15)	
Fat consumption				0.484				0.244				0.086
Rare	108 (80.6)	24 (17.9)	2 (1.5)		90 (78.9)	23 (20.2)	1 (0.9)		198 (79.4)	47 (19.0)	3 (1.2)	
Frequent	573 (81.5)	109 (15.5)	21 (3.0)		516 (76.6)	139 (20.6)	19 (2.8)		1.089 (79.1)	248 (18.0)	40 (2.9)	
Everyday	488 (84.2)	77 (13.3)	14 (2.4)		430 (81.0)	86 (16.2)	15 (2.8)		918 (82.7)	163 (14.7)	29 (2.6)	
Fruits and vegetables consumption				0.131				0.664				0.249
Sufficient	19 (100.0)	0 (0.0)	0 (0.0)		23 (82.1)	5 (17.9)	0 (0.0)		42 (89.4)	5 (10.6)	0	
Insufficient	1.150 (82.3)	210 (15.0)	37 (2.7)		1013 (78.5)	243 (18.8)	35 (2.7)		2.163 (80.5)	453 (16.8)	72 (2.7)	
Level of total cholesterol				0.075				<0.001				0.001
Normal (<200 mg/dl)	1.007 (83.5)	170 (14.1)	29 (2.4)		990 (79.5)	226 (18.2)	29 (2.3)		1.997 (81.5)	396 (16.2)	58 (2.4)	
High (>200 mg/dl)	162 (77.1)	40 (19.1)	8 (3.8)		46 (62.2)	22 (29.7)	6 (8.1)		208 (73.2)	62 (21.8)	14 (4.9)	
Level of LDL cholesterol				0.019				<0.001				<0.001
Normal (<130 mg/dl)	965 (83.9)	158 (13.7)	27 (2.4)		967 (80.0)	215 (17.8)	27 (2.2)		1.932 (81.9)	373 (15.8)	54 (2.3)	
High (>=130 mg/dl)	204 (76.7)	52 (19.6)	10 (3.8)		69 (62.7)	33 (30.0)	8 (7.3)		273 (72.6)	85 (22.6)	18 (4.8)	
Level of triglycerides				0.33				0.146				0.886
Normal (<150 mg/dl)	1.026 (82.0)	191 (15.3)	34 (2.7)		913 (79.4)	208 (18.1)	29 (2.5)		1.939 (80.8)	399 (16.6)	63 (12.6)	
High (>=150 mg/dl)	143 (86.7)	19 (11.5)	3 (1.8)		123 (72.8)	40 (23.7)	6 (3.5)		266 (79.6)	59 (17.7)	9 (2.7)	
Level of HDL cholesterol				0.144				0.368				0.486
Normal (>=40 mg/dl)	973 (81.7)	185 (15.5)	33 (2.8)		680 (78.2)	170 (19.5)	20 (2.3)		1.653 (80.2)	355 (17.2)	53 (2.6)	
Low (<40 mg/dl)	196 (87.1)	25 (11.1)	4 (1.8)		356 (79.3)	78 (17.4)	15 (3.3)		552 (81.9)	103 (15.3)	19 (2.8)	

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Table 3.
Multivariate Regression Analysis of Prehypertension Risk Factors in Adolescents based on Riskesdas 2013

Characteristics	Girls			Boys			Overall		
	RRR	95% CI	p-value	RRR	95% CI	p-value	RRR	95% CI	p-value
Pre-hypertension									
Sex									
Girls							1		
Boys							1.48	(1.10 - 1.97)	0.01
Age (years)									
15	1			1			1		
16	1.62	(0.77 - 3.42)	0.202	0.21	(0.06 - 0.72)	0.013	0.83	(0.46 - 1.49)	0.531
17	1.54	(0.74 - 3.21)	0.245	0.91	(0.42 - 1.95)	0.804	1.21	(0.72 - 2.05)	0.47
18	15.33	(8.16 - 28.83)	<0.001	14.45	(7.79 - 26.80)	<0.001	14.64	(9.39 - 22.80)	<0.001
19	12.21	(6.30 - 23.65)	<0.001	33.42	(17.17 - 65.05)	<0.001	19.89	(12.41 - 31.88)	<0.001
Level of education completed									
Primary school or no schooling	1			1			1		
Junior Highschool	0.91	(0.59 - 1.40)	0.672	0.73	(0.46 - 1.15)	0.179	0.83	(0.61 - 1.14)	0.253
Senior Highschool	0.71	(0.45 - 1.12)	0.142	0.75	(0.47 - 1.21)	0.239	0.7	(0.51 - 0.98)	0.036
Working status									
Not working				1			1		
Student				1.4	(0.90 - 2.18)	0.138	1.1	(0.83 - 1.46)	0.495
Currently working				1.13	(0.72 - 1.78)	0.598	0.92	(0.67 - 1.27)	0.622
Still look for job				1.44	(0.73 - 2.84)	0.289	1.45	(0.87 - 2.40)	0.15
Nutritional status									
Normoweight				1			1		
Underweight				0.54	(0.33 - 0.86)	0.01	0.66	(0.47 - 0.95)	0.024
Overweight				2.02	(0.84- 4.86)	0.116	1.58	(0.98 - 2.55)	0.061
Obese				2.72	(0.73- 10.13)	0.136	2.16	(1.02 - 4.58)	0.043
Central obesity									
No				1					
Yes				1.71	(0.67 - 4.35)	0.258			
Smoking behavior									
Never smoked							1		
Ever smoked							0.72	(0.34 - 1.53)	0.397
Currently smoking							1.05	(0.75 - 1.46)	0.784
Level of total cholesterol									
Normal (<200 mg/dl)							1		
High (>200 mg/dl)							1.14	(0.67 - 1.93)	0.63

Level of LDL cholesterol									
Normal (<130 mg/dl)	1			1			1		
High (>=130 mg/dl)	1.48	(1.01 - 2.16)	0.046	1.6	(0.94 - 2.74)	0.085	1.4	(0.88 - 2.22)	0.154

Table 4.
Multivariate Regression Analysis of Hypertension Risk Factors in Adolescents based on Riskesdas 2013

Hypertension									
Sex									
Girls							1		
Boys							1.16	(0.64 - 2.12)	0.625
Age (years)									
15	1			1			1		
16	0.82	(0.25 - 2.64)	0.738	1.75	(0.40 - 7.67)	0.458	1.17	(0.48 - 2.89)	0.73
17	1.19	(0.43 - 3.32)	0.739	1.69	(0.39 - 7.24)	0.482	1.45	(0.63 - 3.37)	0.383
18	2.2	(0.75 - 6.40)	0.149	4.92	(1.15 - 21.00)	0.031	3.06	(1.28 - 7.34)	0.012
19	0.9	(0.23 - 3.49)	0.877	13.06	(2.95 - 57.75)	0.001	3.25	(1.25 - 8.41)	0.015
Level of education completed									
Primary school or no schooling	1			1			1		
Junior Highschool	1.15	(0.46 - 2.87)	0.761	1.06	(0.40 - 2.79)	0.898	1.16	(0.60 - 2.26	0.651
Senior Highschool	1.72	(0.62 - 4.80)	0.299	1.33	(0.47 - 3.81)	0.591	1.47	(0.70 - 3.10)	0.313
Working status									
Not working				1			1		
Student				1.34	(0.51 - 3.52)	0.558	0.98	(0.54 - 1.78)	0.956
Currently working				1.89	(0.72- 4.94)	0.195	1.38	(0.70 - 2.73)	0.353
Still look for job				1.77	(0.42 - 7.30)	0.431	1.5	(0.52 - 4.31)	0.451
Nutritional status									
Normoweight				1			1		
Underweight				0.25	(0.06 - 1.10)	0.066	0.42	(0.15 - 1.20)	0.105
Overweight				0.26	(0.03 - 2.48)	0.243	1.32	(0.51 - 3.38)	0.566
Obese				2.27	(0.38 - 13.43)	0.365	5.69	(2.20 - 14.8)	<0.001
Central obesity									
No				1					
Yes				5.15	(1.36 - 19.47)	0.016			
Smoking behavior									
Never smoked							1		
Ever smoked							0.51	(0.07 - 3.88)	0.512
Currently smoking							1.18	(0.58 - 2.40)	0.638
Level of total cholesterol									
Normal (<200 mg/dl)							1		
High (>200 mg/dl)							1.21	(0.44 - 3.34)	0.707
Level of LDL cholesterol									
Normal (<130 mg/dl)	1			1			1		
High (>=130 mg/dl)	1.7	(0.81 - 3.58)	0.163	3.15	(1.31 - 7.56)	0.01	1.88	(0.75 - 4.71)	0.177

DISCUSSION

Hypertension today is not just a health problem for adults, both in Indonesia and globally. Among overall adolescents in this study, there was an increase in blood pressure already detected in the younger age group (15-19 years) with the prevalence of prehypertension and hypertension of 16.8% and 2.6%, respectively. Compared with Indonesian adolescents, systematic reviews reported a lower prevalence of prehypertension, 10% in India, 12.7% in Africa, and 9.67% globally [24–26]. The prevalence in this study is quite worrying, as almost 20% of Indonesian adolescents are already prehypertensive, the strongest risk factor for being hypertensive [27].

Early-stage hypertension rarely shows symptoms; however, along with the increasing prevalence of obesity in children and adolescents, it increases the risk of hypertension at a younger age [27]. Ironically, there is seldom a measurement of blood pressure in adolescents because the impact of the measurement status is not immediately visible, and tends to be negligible when compared to adults [28]. Meanwhile, the hypertension prevalence in Indonesian adolescents is similar to that reported in the US adolescents (2.7%) but smaller than global (4%), Indian (roughly 7%), and African (5.5%) adolescents as well as teenagers in low-middle-income countries (LIMCs) (9.8%) [24–26,29–31].

Variations in the prehypertension and hypertension prevalence in Indonesia and other countries may be due to differences in subjects' characteristics or research methods. Cheung *et al.* (2017) reported that the hypertension prevalence varied among African-American, Hispanic, white, and Asian students in Houston, America, where the African-Americans have the highest prevalence among the four ethnic groups. Besides that, the age range of the subjects reported in the previous studies was wider than in this study, namely Africa 2-19, India 4-19, global 6-19, and India 10-19 years [24–26,30]. More prehypertension or hypertension status was likely to occur, which may eventually contribute to the higher reported prevalence. Differences in prevalence between countries can also be a result of differences in the sampling methods. The subjects in this study represent the national population because the sample design was intended for this purpose [14]; whereas the Indian and African meta-analyses involved subjects at the subnational level only [25,30]. Differences in how hypertension status is determined may also explain differences in the prevalence of hypertension across countries. This study measured adolescent blood pressure at least twice on one occasion/visit, while previous studies measured it on at least 3 separate occasions referring to The US 4th Report by the National High Blood Pressure Education Program (NHBPEP) Working Group [24,26]. Thus, the prevalence may vary between Indonesia and other countries due to the measurement method difference.

The study also showed that, across overall adolescents, older age was a risk factor for prehypertension and hypertension. It is similar to that reported by various studies where blood pressure increased rapidly with age and during puberty, which was more prevalent in boys than girls [32–35]. Research in China also found that adolescent puberty rates were associated with increased blood pressure [33].

The primary outcome of this study is that obesity is a risk factor for hypertension in adolescents, which confirms various studies worldwide [36–38]. A systematic review shows that the pathophysiology of hypertension in obese adolescents is complex. Several relevant factors include the endocrine system involving the renin-angiotensin-aldosterone system, corticosteroids and adiponectin, family history of hypertension, birth weight history, sleep patterns, and other clinical histories such as hyperuricemia [11,39]. Many studies and literature have reported obesity as one of the determinants of hypertension, and controlling adolescent obesity is one of the opportunities for intervention that can be implemented early [40].

We also present the results of the by-sex stratification analysis for both prehypertension and hypertension. The results show that older age, central obesity, and high LDL cholesterol are risk factors for hypertension in male adolescents, whereas there are no significant risk factors for hypertension in their female counterparts. A meta-analysis of 55 studies with a sample of 122,053 adolescents reported that the prevalence of increased blood pressure in males was 11.2% and occurred mostly in male adolescents in low-middle income countries [31]. The sex-hypertension association is related to sex hormones, which have the potential impact on blood pressure. Estrogen inhibits the renin-angiotensin system causing a decrease in blood pressure. On the other hand, testosterone increases the renin-angiotensin system which makes blood pressure rise [41,42].

Another risk factor related to hypertension in teenage boys is central obesity. Previous studies have shown that central obesity is a strong predictor of hypertension incidence [43] and a study in India reported that an abdominal circumference of 90 cm was associated with hypertension in adult males [44]. A study on Indonesian adolescents found that the average waist circumference of boys was higher than that of girls. In the study, the best cut-off value for the abdominal circumference to predict adolescent hypertension for <15 years of age was 90.1 cm; whereas, in adolescents 15 years the values were 103.5 cm and 104.85 cm to predict both systolic and diastolic hypertension [45]. Although the literature has provided this recommendation, the issue of central obesity in adolescents has not received sufficient attention to prevent non-communicable diseases in the future.

As for LDL cholesterol, this study showed that it is a risk factor for hypertension in male adolescents as well as a risk factor for prehypertension in female adolescents. This result is in line with a literature review concluding that hypertensive adolescents had high LDL cholesterol levels [46]. The results of a study in Germany showed that among 5,629 boys with a median age of 10 years, boys with prehypertension (11.2%) were likely to have higher LDL cholesterol levels than the ones with normal blood pressure (8.2%) (Haas, Bertsch, and Schwandt 2014). The elevated total and LDL cholesterol are precursors of atherosclerosis that cause coronary heart disease in adulthood [47]. Based on this and other studies, screening and efforts to change health behaviors from adolescence are important to manage risk factors for future heart and vascular disease.

This study concluded that older adolescents and obesity are the risk factors for prehypertension and hypertension in adolescents. Older adolescents are in the stage of puberty which is associated with an increase in blood pressure [33]. Many studies also reported that blood pressure increases rapidly with age and during puberty and it is experienced by more adolescent boys than girls [32–35]. A study in China also confirmed that obesity is the risk factor for hypertension in adolescents [33,36,37]. A systematic review explained complex hypertension pathophysiology in obese adolescents which is related to endocrine factors involving the renin-angiotensin-aldosterone system, corticosteroids and adiponectin, family history of hypertension, history of birth weight, sleep pattern, and hyperuricemia [11,39]. Therefore, obese adolescents should be intervened immediately to prevent hypertension in this group [40].

Results of analysis stratified by sex showed that older age, central obesity, and high LDL cholesterol are the risk factors for hypertension among adolescent boys; meanwhile, there are no significant risk factors in adolescent girls. This result is supported by a meta-analysis of 55 studies on 122.053 adolescents which concluded that the prevalence of elevated blood pressure in boys is 11.2% and mostly found in low- and middle-income countries (LMICs) adolescent boys [31]. Sex hormones have an important role in blood pressure, for example, estrogen can inhibit the renin-angiotensin system which causes a decrease in blood pressure whereas testosterone can increase the renin-angiotensin system that leading to further increases in blood pressure [41,42].

This study also found that central obesity is associated with hypertension among adolescent boys. A previous study in Brazil supported this study which describes central obesity as a strong predictor of hypertension incidence in adult males [43]. In addition, an Indian study also confirmed this result which reported waist circumference ≥90 cm is significantly related to hypertension among adult men [44]. Indonesian adolescent study found that boys had higher waist circumference compared to girls, suggesting waist circumference of 90.1 cm is the best cut off to predict hypertension among adolescent aged <15 years old; meanwhile waist circumference of 103.5 cm and 104.85 cm is the best cut off to predict hypertension among those who aged ≥15 years old [45]. Therefore, addressing obesity and the central obesity problem is an important priority to fight the continuous rise for hypertension in adolescents.

This study revealed that LDL cholesterol is the risk factor of hypertension among adolescent boys and girls. A literature review confirmed this result which reported that higher LDL cholesterol is found in hypertension adolescents [46]. A study in Germany showed that among 5.629 boys the average age of 10 years old, prehypertension boys (11.2%) tend to have higher LDL cholesterol than those who have normal blood pressure (8.2%) [48]. Elevated total cholesterol and LDL is atherosclerosis precursor that leads to coronary heart diseases in adulthood [47]. These pieces of evidence emphasize the need to detect hypertension risk factors early and practice a healthy lifestyle since childhood. Hence, healthy lifestyle interventions such as healthy eating behavior, physical activity, and regular blood pressure monitoring should be a national strategy to control prehypertension and hypertension among adolescents [32].

Currently, health service for school-aged children and adolescents is one of the key performance indicators of the Indonesian Ministry of Health that is implemented through school health promotion (SHP) and adolescent-friendly health service (AFHS) program [49]. In AFHS, health services related to non-communicable diseases (NCD) prevention are early detection through the family history of the disease, blood pressure measurement, blood sugar, and cholesterol tests, providing communication and education about balanced nutrition and obesity prevention, counseling and referrals if found more than 1 risk factor for NCDs. Meanwhile, SHP activities include anthropometric measurements and nutritional status evaluation, as well as physical activities through stretching exercises together at school [50,51].

In addition, integrated healthcare posts (IHP) for adolescent in each hamlet has been promoted since 2018 to increase access and coverage of adolescent health services, such as anthropometric measurements and blood pressure [52]. This policy was strengthened by the national action plan to improve the welfare of school-aged children and adolescents in 2022 which involves multi-sectors to manage intervention in reducing poor diet, anemia, malnutrition, and obesity among school-aged and adolescents [53].

Early detection of NCDs program by the government is currently for the adult population aged 15 years and above, meaning that national evaluation for NCDs hasn't reached the young adolescent group yet [49]. Although NCDs early detection is part of activities in SHP and AFHS, national data related to specific NCDs among adolescents is still limited [50]. Data in Indonesia's health profile 2020 is still limited to school units, namely the percentage of schools receiving student health services, 81.9% for junior high school, and 79.1% for senior high school [51]. Therefore, this study suggests the importance of national policy for early detection, diagnosis, monitoring, and evaluation of hypertension and its risk factors among school-aged children and adolescents.

This study has limitations. The cross-sectional design used in this study is only able to describe prevalence variation and correlation among factors related to hypertension, not causality. In addition, the method of blood pressure measurement differs from the global guidelines, allowing for potential bias in hypertension determination. The relationship between hypertension and puberty, sodium intake, food consumption, and family history of hypertension were not able to explore in this study due to limited data. The prevalence of prehypertension and hypertension in this study didn't involve young adolescents aged 10-14 years, thus it may lead to data underreporting. Despite these limitations, this study has the strength of a large sample size that represents the national population, hence, the prevalence of prehypertension and hypertension among adolescents can accurately reflect the condition of the Indonesian adolescent population.

CONCLUSION

This study revealed that almost 3% of adolescent have hypertension whilst prehypertension has been detected in nearly one-fifth of adolescents which were higher in boys than girls. Different risk factors for prehypertension and hypertension in adolescent boys and girls were also detected. Older age and high LDL cholesterol were risk factors in prehypertension adolescent girls. Risk factors of hypertension among adolescent boys were older age, had central obesity, and high LDL cholesterol. Addressing prehypertension and hypertension should be a government priority to prevent and control NCDs among adolescents. Regular measurement of blood pressure, blood cholesterol, and anthropometry are critical to detect, diagnose, and monitor early the risk factors of hypertension during adolescence.

Contributorship statement S contributed to the manuscript conception, study design, definition of intellectual contents, statistical analysis, and manuscript preparation. RM contributed to literature search, data acquisition, data analysis, background and results. RR contributed to literature search, discussion, manuscript editing, and manuscript review. PA contributed to literature search, results, discussion, manuscript editing, and manuscript review. TP contributed to literature search, discussion, manuscript editing, and manuscript review. All authors have read and approved the content in this manuscript.

Competing interests. All manuscript contributors declare no conflict of interest.

Funding. The authors received no financial support for the research, authorship, and/or publication of this article.

Data sharing statement All data generated or analyzed during this study are included in this published article and its supplementary files. The data that support the findings of this study are available from the Data Management Laboratory of the National Institute of Health Research and Development (NIHRD), Ministry of Health of Indonesia. Data can be made available after approval of a written request to the Data Management Laboratory—NIHRD at mandat@litbang.depkes.go.id/labmandat.litbangkes@gmail.com.

Ethics approval

The implementation of Riskesdas in 2013, has obtained ethical approval from the Health Research Ethics Commission (KEPK), the Health Research and Development Agency of the Ministry of Health of the Republic of Indonesia with the number: LB.02.01/5.2/KE.006/2013. All respondents gave written consent after being given an explanation and before data collection was carried out. Health research ethical guidelines have been followed including consent, voluntary participation, confidentiality, and anonymity.

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02/Permenko PMK No 1 Tahun 2022 ttg RAN KAUSR.pdf

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	19
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence and Associated Factors for Prehypertension and Hypertension among Indonesian Adolescents: A cross-sectional community survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2022-065056.R1
Article Type:	Original research
Date Submitted by the Author:	06-Mar-2023
Complete List of Authors:	Sudikno, Sudikno; National Research and Innovation Agency Republic of Indonesia Mubasyiroh, Rofingatul; National Research and Innovation Agency Republic of Indonesia Rachmalina, Rika; National Research and Innovation Agency Republic of Indonesia Arfines, Prisca; National Research and Innovation Agency Republic of Indonesia Puspita, Tities; National Research and Innovation Agency Republic of Indonesia
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	Hypertension < CARDIOLOGY, EPIDEMIOLOGY, Community child health < PAEDIATRICS, PUBLIC HEALTH, Adolescent

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Prevalence and Associated Factors for Prehypertension and Hypertension among Indonesian Adolescents: A cross-sectional community survey

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Keywords: prehypertension, hypertension, adolescents, nutritional status, lipid profile

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Word count - excluding title page, Contributorship statement, Competing interests ,

Funding, Data sharing statement, references, figures and tables: 5332

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ABSTRACT

Objective: To estimate the prevalence and determine the associated factors for developing prehypertension and hypertension among Indonesian adolescents.

Design: National cross-sectional study

Setting: This study was conducted in all the provinces in Indonesia.

Participants: The population in this study were all household members in Basic Health Research 2013 aged 15-19 years. The sample was all members of the 2013 Riskesdas household aged 15-19 years with the criteria of not having physical and mental disabilities, and having complete data. The number of samples analyzed was 2735, comprising men (n = 1319) and women (n = 1416).

Main Outcome: Dependent variables were prehypertension and hypertension in adolescents based on blood pressure measurements.

Results: The results of the analysis showed that the prevalence of pre-hypertension in adolescents was 16.8% and hypertension was 2.6%. In all adolescents, the risk factors for prehypertension were female (aOR 1.48; 95% CI 1.10-1.97), 18 years old (aOR 14.64; 95% CI 9.39-22.80), and 19 years old (aOR 19.89; 95% CI 12.41-31.88), and obese (aOR 2.16; 95% CI 1.02-4.58). Risk factors for hypertension in all adolescents included the age of 18 years old (aOR 3.06; 95% CI 1.28-7.34) and 19 years (aOR 3.25; 95% CI 1.25-8.41) and obesity (aOR 5.69; 95% CI 2.20-14.8). In adolescent girls, the chance of developing prehypertension increased with increasing age and Low-Density Lipoprotein (LDL) cholesterol levels. Several risk factors for hypertension in adolescent boys were age, central obesity, and LDL cholesterol levels.

Conclusion: This study shows that the trend of prehypertension in adolescents has appeared, besides hypertension. There are distinct patterns of factors that influence it in adolescent girls and boys, which can be useful to sharpen of planning and implementing health programs.

Keywords: prehypertension, hypertension, adolescents, nutritional status, lipid profile

Strengths and limitations of this study

- The data on prehypertension and hypertension in adolescents that we presented may enrich the evidence base of NCD at a young which has rarely been discussed in our country.
- In this study, hypertension status was obtained based on measurement results not only from the respondent's acknowledgment.
- Several independent variables were also based on measurement results, such as BMI, abdominal circumference, and lipid levels.
- The cross-sectional design of the study did not show a causal relationship.
- Several important independent variables that were not involved in the analysis: parental history of hypertension, and food consumption.

INTRODUCTION

Non-communicable diseases (NCDs) are the leading cause of death globally, with 41 million people each year, equivalent to 71% of all deaths.[1] Indonesia's latest condition in 2020 depicted that NCDs accounted for 73% of total deaths (1,365,000 deaths because of NCDs), and 26% of premature deaths because of NCDs.[2] Globally, the number one metabolic risk factor for NCD death is elevated blood pressure, which causes 19% of global deaths, followed by overweight/obesity, and elevated blood glucose.[1] Meanwhile, the total NCD burden for adolescents aged 10-14 years in the Southeast Asia region is 47.37% for boys and 51.31% for girls; and for adolescents aged 15-19 years is 44.76% for boys and 46.82% for girls.[3] High systolic blood pressure that begins in adolescence becomes a leading NCD risk factor in youth and adulthood. It contributes to 12.8% of disability-adjusted life years (DALYs) in ages 15-49 years and 30.7% of DALYs in ages 50-69 years.[3]

Hypertension is often associated with a disease in adults and the elderly, but the trend of hypertension at a young age also cannot be underestimated. The results of monitoring through a national survey in Indonesia in 2007 reported that hypertension at 15-17 years reached a quarter (8.4%) of the prevalence at 18 years and over (31.7%).[4] The risk factors for hypertension in Indonesian adolescents have also increased. We can see this from the monitoring of the Global School-based Student Health Survey (GSHS) in 2007-2015, the obesity indicator increased from 1.3% to 4.9%, and for overweight from 5.8% to 8.4%. The prevalence of fruit consumption declined from 69.6% to 63.9%. While vegetable consumption decreased from 83.3% to 82.15% and the indicators of daily physical activity of at least 60 minutes per day also decreased from 16.5% to 12.23%.[5,6] Another condition that also needs to be watched out for was a quarter (25.9%) of adolescents aged 13-18 years had consumed >2000 mg of daily sodium.[7] These worsening indicators of hypertension risk factors were alarming for an increase in hypertension in adolescents. The impact of hypertension on adolescents may be seen including damage to several organs of the body which is proven to occur in adolescents with hypertension such as left ventricular hypertrophy, retinopathy, and microalbuminuria.[8] Not only the problem of hypertension is a concern, but the condition of prehypertension also cannot be ruled out. In a meta-analysis of cohort studies, patients with prehypertension had a greater risk of having a stroke, myocardial infarction (MI), and cardiovascular (CVD).[9] Data on prehypertension at 40 years of age and older in Indonesia in the year 2014 was around 32.5%.[10]

A systematic review of 50 cohort studies from the United States, Europe, Asia, Australia, Canada, Israel, and New Zealand showed that increased blood pressure in childhood is a predictor of adult hypertension, and this condition requires early intervention.[11] Boys and girls, with the influence of puberty, had different blood pressure patterns.[12] This pattern also may have had different paths to adult hypertension.[11]

By 2045, nearly 60 percent of Indonesia's population would be dominated by those under the age of 30. We can say that Indonesia would get a demographic bonus. It means that the productive and educated age group would have a larger population than the one in the previous period. This demographic bonus would have appeared as a gift, but if it is not maintained properly, it would become a disaster. If the health investment of young people were not supported, then this population of productive age would become a liability, not an asset.[13]

Given the enormous potential of the adolescent group and the risk of developing hypertension, we aimed to know the magnitude of the problem and the factors associated with the incidence of prehypertension and hypertension in Indonesian adolescents. Therefore, we would use it in sharpening the hypertension control programs for the adolescent group.

METHODS

Study Design and Population

This study employed secondary data from Indonesian Basic Health Research 2013 collected from 33 provinces. The study design was cross-sectional. The population in this study were all household members in Basic Health Research 2013 aged 15-19 years. While the sample was all members of the 2013 Basic Health Research household aged 15-19 years with the criteria of not having physical and mental disabilities and having complete data. The number of samples at the beginning of the analysis was 2,966. After data checking of the outliers of height, weight, and several variables, as well as the completeness of the data, the number of samples analyzed remained around 2,735. Based on our study's findings, which showed that the proportion of prehypertension in the normoweight group was 16.2% and the aOR of prehypertension in the obese group was 2.1, our entire sample met the minimum sample power requirement of 90% for the hypothesis test for an odds ratio.[14]

Measurements

The data collected in this study included demographic characteristics, health conditions of non-communicable diseases, and health-related behavior. Data were collected through face-to-face interviews by the enumerators with trained health backgrounds, who conducted household visits. The respondent's health conditions were measured including blood pressure, weight, height, and abdominal circumference which were also carried out by enumerators at the respondent's home. Firstly, data were collected and recorded on a paper questionnaire and then entered into the data entry program on the computer. The process of collecting data in the field was monitored by a person in charge of the field at the district/city level, to ensure data quality.

Blood pressure measurements were carried out on respondents aged 15 years and over. Measurement of blood pressure was conducted using a digital tensimeter/digital tensimeter Omron brand type IA1 and measurements were made on the left arm. At least thirty (30) minutes before measuring blood pressure, respondents were asked not to engage in physical activity such as exercise, smoking, eating, drinking coffee, or consuming alcohol.

Measurements were not taken when the respondent was under stress, including the condition of holding back the urge to urinate. Make sure the respondent's bladder is empty. Respondents were asked to wear thin, short-sleeved, or loose-fitting clothes. If the sleeves are long, the left sleeve is rolled up so that the cuff can rest directly against the skin of the arm. The folds of the clothes should not be tight because they can block the blood flow in the arms. Measurements should be taken in a quiet room. Respondents sat resting for 5–10 minutes before the measurement. The respondent sits relaxed, with their legs not crossed and both feet flat on the floor. Place the left arm with the respondent's elbow resting on the table so that the cuff can be placed at the level of the respondent's heart. The forearms should not be tense with open palms facing up. The respondent must remain seated upright without moving much and may not talk or laugh during the measurement because it will affect the measurement results. Each respondent was measured at least 2 times. If the result of the second measurement was different by 10 mmHg compared to the first measurement, a third measurement was carried out. The two-measurement data with the smallest difference from the last measurement were calculated on average as the result of measuring blood pressure.[15]

Measurements of height and weight were carried out for all respondents, all age groups, and genders. Height measurements were not carried out for respondents who were seriously ill, had limitations in following the measurement procedure, and were pregnant women. This measurement procedure was carried out by two enumerators with one should perform as the measurer and the other as a recorder of the measurement results. The weight measurement equipment used a digital scale from the Fesco brand with an accuracy of 0.1 kg. The instrument calibration was carried out every day before collecting data[16] Measurement of height was performed using a "Multifunctional height measuring" instrument with a length capacity of two meters and an accuracy of 0.1 centimeters.[16]

Measurement of abdominal circumference was conducted using a Medline tape measure. All anthropometric measurements were carried out using measurement guidelines.[16] The measurements were performed by sticking a measuring tape directly on the skin, with no clothes, and sticking the tape to the stomach area. The measuring point was determined by finding the midpoint between the edge of the lowest rib and the endpoint of the hip bone arch. Measurement was conducted by drawing a parallel/horizontal line around the waist and abdomen.

The biomedical examination of the respondents was carried out after signing the informed consent. This biomedical examination was carried out on respondents who were at least 15 years old. The procedure of biomedical examination included taking a venous blood sample of around 10 ccs and then the sample was analyzed at the National Institute of Health Research and Development Laboratory in Jakarta. The clinical chemistry examinations were carried out automatically using Cobas(R) Roche (Chol2, Crep2, HDLC3, LDL_C, Trigl) with colorimetric enzymatic principles for several tests, namely total cholesterol, HDL, direct LDL, triglycerides, and creatinine.[17]

Measurement of physical activity variables was based on a composite calculation of the type and duration of activity (days per week and minutes per day) including the exercise performed. Data were collected by asking about physical activity habits/physical activities related to work and leisure time which included heavy, moderate, and sedentary physical activity with a duration of more than 10 minutes continuously. The number of active days in the week and the duration of the activity will be converted into METs. For heavy activity or heavy exercise, it weighed 8 times. While moderate activity or moderate exercise weighed 4 times, and light activity weighed 2 times. Subjects were categorized as less active if they have a total activity of less than 600 METs (metabolic equivalent) in a week.[18]

Consumption of fruit and vegetables was assessed by calculating the number of days of consumption in a week and the number of servings of average consumption in a day. After that, the category was categorized as 'enough' if the subject consumed fruit and/or vegetables in at least 5 portions per day for 7 days a week. Then it would be categorized as 'less' if the consumption of vegetables and/or fruit was less than 5 portions per day for 7 days a week.[16]

The instruments in this survey have been validated through pilot tests in the target population in two locations in Indonesia. The pilot test included testing on the flow of questions in the questionnaire, the measurement tools being used, the data entry programs, and the collection of biomedical specimens. The trials were carried out in collaboration between researchers, academics (from 3 universities in Indonesia), and professional organizations. Details on this survey method can be found elsewhere[15].

Outcome Variable

The main outcome variables in this study were prehypertension and hypertension in adolescents. The results of blood pressure measurements were categorized as prehypertension if the average Systolic Blood Pressure (SBP) and/or Diastolic Blood Pressure (DBP) levels were greater than or equal to the 90th percentile, but less than the 95th percentile. Then for hypertension, if the average of SBP and/or DBP were greater than or equal to the 95th percentile.[19] For subjects aged 18-19 years, prehypertension was categorized if the SBP value was greater than 120-139 mmHg and/or if the DBP was greater than 80-89 mmHg. Whereas, hypertension for subjects aged 18-19 years was determined by an SBP greater than or equal to 140 mmHg and/or DBP greater than or equal to 90 mmHg (according to JNC VII).[20]

Independent variables

The independent variables consisted of individual characteristics, gender, marital status, age, occupation, education level, residency, smoking behavior, physical activity, fruit and vegetable eating habits, fatty/fried food habits, BMI, and lipid profile. Then those were categorized as follows: gender (male and female), age group (15-17 years old and 18-19 years old), highest education level completed with proof of graduate certificate (less than elementary school, junior high school, and high school), marital status (unmarried and married), employment status (not working, school, working and looking for work), residency (urban and rural), physical activity (enough, and less), smoking (never smoked, ever smoked, and currently smokes), fruit and vegetable consumption (enough, less), and habits on fatty/fried foods consumptions which were grouped according to the frequency of consumption (rare if 3 times of consumption/month, often if 2-6 times/week, and daily if consume ≥ 1 time/day).

Metabolic syndrome variables consisted of several variables including total cholesterol, low-density lipoprotein cholesterol (LDL), triglyceride (TG), high-density lipoprotein cholesterol (HDL), hypertension, and Diabetes Mellitus. The total cholesterol (Chol-total) was grouped as 1. normal (if the value <200 mg/dL) and 2. high (if the value ≥200 mg/dL). The LDL cholesterol (Chol-LDL) level was grouped as 1. normal (if the value <100 mg/dL) and 2. high (if the value ≥100 mg/dL). The HDL cholesterol (Chol-HDL) level was grouped as 1. normal if the value was more than 40 mg/dL (men) or if the value was more than 50 mg/dL (women) and 2. low if the value <40 mg/dL (men), or if the value <50 mg/dL (female). Meanwhile, the triglyceride (TG) level was grouped into 1. normal (if the value was <150 mg/dL) and 2. high (if the value was ≥150 mg/dL).[21,22]

Assessment of nutritional status was carried out using 2 criteria, where the age group was younger or equal to 18 years using the BMI-for-age z-score (BAZ) indicator and for those aged 19 years using the Body Mass Index calculation. To assess nutritional status using the BAZ indicator, the weight and height values of each subject were converted into standardized values (z-score) using the 2005 WHO child anthropometry reference. Furthermore, based on the Z Score value of each of these indicators, nutritional status was determined with limit values as follows: thin (BAZ<-2 SD), good/normal (BAZ≥-2 SD - -2 SD), obese (BAZ>2 SD). Analysis of the conversion of weight and height into BMI (nutritional status) using the formula of weight (meters) divided by height squared (m^2) then categorized based on the BMI category according to WHO (2000), namely: underweight (BMI<18.5 kg/m2), good/normoweight (BMI= 18,5-24,9 kg/m2), overweight (BMI= 25,0-29,0 Kg/m^2) and obese (BMI≥30,0 kg/m^2).[23]

Central obesity was assessed using the abdominal circumference of adolescents aged 18 years or younger using the P90 cut-off by sex and age for children and adolescents of 6–18-year-old[24] and at age 19 years using the International Diabetes Federation and the Indonesian Ministry of Health recommended cut-off for adult (for women >80 cm and men > 90 cm).[25]

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Data analysis

Data management was intended on survey data to maintain the quality of the data that has been collected. All data management activities were organized and carried out by the research team. Data management consisted of a series of activities starting from the development of data entry programs, the process of sending and receiving data from the enumerator to the central data team, editing and coding, and data cleaning. Data amputation has also been performed on variables that require it. Furthermore, the data is ready to be analyzed. Data entry has been conducted at the research location by the enumerator using the CS Pro-based data entry program.[26]

Data analysis was carried out in stages including univariate, bivariate, and multivariate analysis. Univariate analysis was intended to determine the distribution of the value of each variable. While the bivariate analysis aimed to determine crude associations of each risk factor variable and hypertension by using the Chi-square test and bivariate logistic regression. Furthermore, multivariate analysis was carried out to determine the association for every hypertension risk factor in adolescents using multivariate multinomial logistic regression. The odds ratio was used as a measure of association. A stepwise process with backward elimination and a rejection criterion of the p-value greater than 0.05 was used to create a final explanatory model with a subset and relative odds ratio (OR) of the components associated with hypertension. All analyses were performed using Stata S.E. 15.

RESULTS

Sociodemographic characteristics

Table 1. shows a description of the characteristics of the girls and boys who participated in this study. Of the total 2,725 individuals, 1,416 were female and 1,319 were male. In general, the majority of respondents were 17 years old (23%), unmarried (94.3%), junior-high-school graduates (48.9%), and current work status as students/schooling (49.5%). Regarding the location of residence, 52.3% were in rural areas. Some characteristics which were related to health, the majority of adolescents were underweight (80.6%), did not have central obesity (89.4%), had an insufficient/less level of physical activity (84.1%), and had never smoked (76.3%). When viewing the characteristics of food consumption, most of the respondents admitted that they often consumed fat (50.4%) and consumed less fruit and vegetables (98.3%). Based on the lipid profile measurement, it was found that the percentage of adolescents with high total cholesterol levels (>200 mg/dl) was around 10.4%, high LDL cholesterol levels (>=130 mg/dL) reached 13.8%, had high triglyceride levels (>= 150 g/dL) at around 12.2%

and with low HDL cholesterol levels (<40 mg/dL) reached 24.6%. In this study, the proportion of students with hypertension was 2.6% and pre-hypertension was 16.8%.

Sociodemographic and health characteristics were different between boys and girls significantly for marital status, education level, working status, nutritional status, central obesity, physical activity, smoking behavior, total cholesterol level, LDL cholesterol level, HDL cholesterol level, and on hypertension pattern. There was a difference in marital status whereas married status was more common in girls. From the characteristics of working status, there were more boys who participated in working compared to girls. In addition, girls had a higher level of education than boys. Differences based on nutritional status found that girls tended more overweight, obese, and had central obesity than boys. Girls were less physically active than boys. Boys were more likely than girls to engage in smoking behavior. High levels of total cholesterol and LDL cholesterol were more common in girls. While low HDL levels were more common in boys than girls. Pre-hypertension was higher in boys than girls, but the prevalence of hypertension did not differ between girls and boys (Table 1).

Table 1. Sociodemographic and health-related characteristics of 2,735 participants in the 2013 Riskesdas, in total and by gender

Characteristics	Girls		Boys		p-value	Total	
	n=1,416	%	n= 1,319	%		n=2,735	%
Age (years)					0.736		
15	321	22.7	298	22.6		619	22.6
16	270	19.1	260	19.7		530	19.4
17	340	24	289	21.9		629	23
18	273	19.3	270	20.5		543	19.9
19	212	15	202	15.3		414	15.1
Marital status					<0.001		
Not married yet	1,282	90.5	1,296	98.3		2,578	94.3
Married	134	9.5	23	1.7		157	5.7
Level of education completed					0.023		
Primary school or no schooling	353	24.9	372	28.2		725	26.5
Junior Highschool	686	48.5	650	49.3		1,336	48.9
Senior Highschool	377	26.6	297	22.5		674	24.6
Working status					<0.001		
Not working	473	33.4	364	27.6		837	30.6
Student	735	51.9	620	47		1,355	49.5
Currently working	163	11.5	266	20.2		429	15.7
Still look for job	45	3.2	69	5.2		114	4.2
Residence					0.826		
Rural	738	52.1	693	52.5		1,431	52.3
Urban	678	47.9	626	47.5		1,304	47.7
Nutritional status					<0.001		
Normoweight	114	8.1	192	14.6		306	11.2
Underweight	1,174	82.9	1,031	78.2		2,205	80.6

Overweight	98	6.9	72	5.5		170	6.2
Obese	30	2.1	24	1.8		54	2
Central obesity					<0.001		
No	1,207	85.2	1,239	93.9		2,446	89.4
Yes	209	14.8	80	6.1		289	10.6
Physically active					<0.001		
Yes/enough	129	9.1	307	23.3		436	15.9
No/less	1,287	90.9	1,012	76.7		2,299	84.1
Smoking behavior					<0.001		
Never smoked	1,405	99.2	682	51.7		2,087	76.3
Ever smoked	6	0.4	71	5.4		77	2.8
Currently smoking	5	0.4	566	42.9		571	20.9
Fat consumption					0.65		
Rare	134	9.5	114	8.6		248	9.1
Frequent	703	49.7	674	51.1		1,377	50.4
Everyday	579	40.9	531	40.3		1,110	40.6
Fruits and vegetables consumption					0.116		
Sufficient/enough	19	1.3	28	2.1		47	1.7
Insufficient/less	1,397	98.7	1,291	97.9		2,688	98.3
Level of total cholesterol					<0.001		
Normal (<200 mg/dl)	1,206	85.2	1,245	94.4		2,451	89.6
High (>200 mg/dl)	210	14.8	74	5.6		284	10.4
Level of LDL cholesterol					<0.001		
Normal (<130 mg/dl)	1,150	81.2	1,209	91.7		2,359	86.3
High (>=130 mg/dl)	266	18.8	110	8.3		376	13.8
Level of triglycerides					0.354		
Normal (<150 mg/dl)	1,251	88.4	1,150	87.2		2401	87.8
High (>=150 mg/dl)	165	11.7	169	12.8		334	12.2
Level of HDL cholesterol					<0.001		
Normal (>=40 mg/dl)	1,191	84.1	870	66		2,061	75.4
Low (<40 mg/dl)	225	15.9	449	34		674	24.6
Hypertension					0.02		
Normotensive	1,169	82.6	1,036	78.5		2,205	80.6
Pre-hypertensive	210	14.8	248	18.8		458	16.8
Hypertensive	37	2.6	35	2.7		72	2.6

Abbreviations: LDL = low-density lipoprotein; HDL = high-density lipoprotein.

Bivariate analysis

The results of the bivariate analysis was presented in Table 2. In general, several risk factors for hypertension and pre-hypertension in adolescents included age, marital status, level of education completed, working status, smoking behavior, total cholesterol levels, and LDL cholesterol levels. Meanwhile, when stratified by gender, the risk factors associated with hypertension and pre-hypertension in girls include age, marital status, education level, working status, and LDL cholesterol levels. Meanwhile, in boys, the risk factors associated with hypertension and pre-hypertension were age, education level, working status, nutritional status, central obesity, smoking behavior, total cholesterol levels, and LDL cholesterol levels (Table 2).

Risk factors associated with Prehypertension and Hypertension among adolescents

Multivariate analysis showed the risk factors for pre-hypertension in all adolescents and by gender (Table 3). In all adolescents, the risk factors for pre-hypertension were female (aOR 1.48 95% CI 1.10-197), at the age of 18 years old (aOR 14.64 95% CI 9.39-22.80), and 19 years old (aOR 19.89 95% CI 12.41-31.88), and obese (aOR 2.16 95% CI 1.02-4.58). Whereas in girls, the chance of developing pre-hypertension increases with increasing age and LDL cholesterol levels. At the age of 18 years and 19 years, the risk for developing pre-hypertension was 15.33 times (95% CI 8.16-28.83) and 12.21 times (95% CI 6.30-23.65) higher when compared to the age of 15 years. Adolescent girls who have a high LDL cholesterol level (>=130 mg/dL) had a relative risk of pre-hypertension around 1.48 times (95% CI 1.01-2.16) higher than those with normal LDL cholesterol levels. Data analysis on boys showed that age was also a risk factor for pre-hypertension where at the age of 18 years and 19 years old the risk was 14.45 times (95% CI 7.79-26.80) and 33.42 times (95% CI 17.17-65.05) higher if compared to 15 years of age. In addition, there were also found protective factors against pre-hypertension including the age of 16 years (aOR 0.21 95% CI 0.006-0.72) and underweight (RRR 0.54 95% CI 0.33-0.68).

Multivariate analysis showed the risk factors for hypertension in all adolescents and by gender (Table 4). Significant risk factors for hypertension in all adolescents included at the age of 18 years old (aOR 3.06 95% CI 1.28-7.34) and 19 years (aORR 3.25 95% CI 1.25-8.41) and obesity (aOR 5.69 95% CI 2.20-14.8). Some factors showed a lower risk of pre-hypertension, which were high school graduates (aOR 0.70 95% CI 0.51-0.98) and underweight (aOR 0.66 95% CI 0.47-0.95). Meanwhile, several risk factors for hypertension in boys were age, central obesity, and LDL cholesterol levels. Older age showed a higher risk of developing hypertension, where at the age of 18 years the risk was 4.92 times (95% CI 1.15-21.00) and at

19 years the risk was 13.06 times (2.95-57.75) higher than at the age of 15 years. Boys who were centrally obese had 5.15 times (95% CI 1.36-1947) higher risk of hypertension than those who were not centrally obese. In addition, boys with a high level of LDL cholesterol (>=130 mg/dL) had 3.15 times (95% CI 1.31-7.56) higher risk than those with normal LDL cholesterol levels for hypertension.

Table 2. Factors Associated to Hypertension and Prehypertension in Adolescents based on Riskesdas 2013, according to sociodemographic and health characteristics

Characteristics	Girls		Boys		Overall	
	Pre-hypertension n (%)	Hypertension n (%)	Pre-hypertension n (%)	Hypertension n (%)	Pre-hypertension n (%)	Hypertension n (%)
Age (years)		***		***		***
15	13 (4.0)	7 (2.2)	17 (5.7)	3 (1.0)	30 (4.8)	10 (1.6)
16	17 (6.3)	5 (1.8)	3 (1.2)	5 (1.9)	20 (3.8)	10 (1.9)
17	19 (5.6)	10 (2.9)	13 (4.5)	6 (2.1)	32 (5.1)	16 (2.5)
18	97 (35.5)	11 (4.0)	105 (38.9)	10 (3.7)	202 (37.2)	21 (3.9)
19	64 (30.2)	4 (1.9)	110 (54.5)	11 (5.4)	174 (42.0)	15 (3.6)
Marital status		***		*		***
Not married yet	171 (13.3)	34 (2.6)	242 (18.7)	34 (2.6)	413 (16.0)	68 (2.6)
Married	39 (29.1)	3 (2.2)	6 (26.1)	1 (4.4)	45 (28.7)	4 (2.6)
Level of education completed		***		***		***
Primary school or no schooling	46 (13.0)	7 (2.0)	59 (15.9)	7 (1.9)	105 (14.5)	14 (1.9)
Junior Highschool	83 (12.1)	16 (2.3)	86 (13.2)	15 (2.3)	169 (12.7)	31 (2.3)
Senior Highschool	81 (21.5)	14 (3.7)	103 (34.7)	13 (4.4)	184 (27.3)	27 (4.0)
Working status		***		***		***
Not working	84 (17.8)	13 (2.8)	67 (18.4)	8 (2.2)	151 (18.0)	21 (2.5)
Student	84 (11.4)	17 (2.3)	81 (13.1)	12 (1.9)	165 (12.2)	29 (2.1)
Currently working	29 (17.8)	5 (3.1)	77 (29.0)	12 (4.5)	106 (24.7)	17 (4.0)
Still look for job	13 (28.9)	2 (4.4)	23 (33.3)	3 (4.4)	36 (31.6)	5 (4.4)
Residence		*		*		*
Rural	118 (16.0)	18 (2.4)	124 (17.9)	14 (2.0)	242 (16.9)	32 (2.2)
Urban	92 (13.6)	19 (2.8)	124 (19.8)	21 (3.4)	216 (16.6)	40 (3.1)
Nutritional status		*		**		***
Normoweight	168 (14.3)	28 (2.4)	190 (18.4)	29 (2.8)	358 (16.2)	57 (2.6)
Underweight	20 (17.5)	2 (1.8)	36 (18.8)	2 (1.0)	56 (18.3)	4 (1.3)
Overweight	16 (16.3)	4 (4.1)	14 (19.4)	1 (1.4)	30 (17.7)	5 (2.9)
Obese	6 (20.0)	3 (10.0)	8 (33.3)	3 (12.5)	14 (25.9)	6 (11.1)
Central obesity		*		**		*
No	174 (14.4)	30 (2.5)	16 (20.0)	6 (7.5)	406 (16.6)	59 (2.4)
Yes	36 (17.2)	7 (3.4)	232 (18.7)	29 (2.3)	52 (18.0)	13 (4.5)
Physically active		*		*		*
Yes/enough	21 (16.3)	2 (1.6)	65 (21.2)	11 (3.6)	86 (19.7)	13 (3.0)
No/less	189 (14.7)	35 (2.7)	183(18.1)	24 (2.4)	372 (16.2)	59 (2.6)
Smoking behavior		*		***		***
Never smoked	206 (14.7)	37 (2.6)	103 (15.1)	16 (2.4)	309 (14.8)	53 (2.5)
Ever smoked	2 (33.3)	0 (0.0)	9 (12.7)	1 (1.4)	11 (14.3)	1 (1.3)
Currently smoking	2 (40.0)	0 (0.0)	136 (24.0)	18 (3.2)	138 (24.2)	18 (3.15)
Fat consumption		*		*		*
Rare	24 (17.9)	2 (1.5)	23 (20.2)	1 (0.9)	47 (19.0)	3 (1.2)
Frequent	109 (15.5)	21 (3.0)	139 (20.6)	19 (2.8)	248 (18.0)	40 (2.9)
Everyday	77 (13.3)	14 (2.4)	86 (16.2)	15 (2.8)	163 (14.7)	29 (2.6)
Fruits and vegetables consumption		*		*		*
Sufficient/enough	0 (0.0)	0 (0.0)	5 (17.9)	0 (0.0)	5 (10.6)	0
Insufficient/less	210 (15.0)	37 (2.7)	243 (18.8)	35 (2.7)	453 (16.8)	72 (2.7)
Level of total cholesterol		*		***		***
Normal (<200 mg/dl)	170 (14.1)	29 (2.4)	226 (18.2)	29 (2.3)	396 (16.2)	58 (2.4)
High (>200 mg/dl)	40 (19.1)	8 (3.8)	22 (29.7)	6 (8.1)	62 (21.8)	14 (4.9)
Level of LDL cholesterol		**		***		***
Normal (<130 mg/dl)	158 (13.7)	27 (2.4)	215 (17.8)	27 (2.2)	373 (15.8)	54 (2.3)
High (>=130 mg/dl)	52 (19.6)	10 (3.8)	33 (30.0)	8 (7.3)	85 (22.6)	18 (4.8)
Level of triglycerides		*		*		*
Normal (<150 mg/dl)	191 (15.3)	34 (2.7)	208 (18.1)	29 (2.5)	399 (16.6)	63 (12.6)
High (>=150 mg/dl)	19 (11.5)	3 (1.8)	40 (23.7)	6 (3.5)	59 (17.7)	9 (2.7)
Level of HDL cholesterol		*		*		*
Normal (>=40 mg/dl)	185 (15.5)	33 (2.8)	170 (19.5)	20 (2.3)	355 (17.2)	53 (2.6)
Low (<40 mg/dl)	25 (11.1)	4 (1.8)	78 (17.4)	15 (3.3)	103 (15.3)	19 (2.8)

Abbreviations: LDL = low-density lipoprotein; HDL = high-density lipoprotein.
Note: ***p<0.01; **p<0.05; *p<0.1

Table 3.
Multivariate Regression Analysis of Prehypertension Risk Factors in Adolescents based on Riskesdas 2013

Characteristics	Girls		Boys		Overall	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
Pre-hypertension						
Sex						
Girls					1	
Boys					1.48**	(1.10 - 1.97)
Age (years)						
15	1		1		1	
16	1.62*	(0.77 - 3.42)	0.21**	(0.06 - 0.72)	0.83*	(0.46 - 1.49)
17	1.54*	(0.74 - 3.21)	0.91*	(0.42 - 1.95)	1.21*	(0.72 - 2.05)
18	15.33***	(8.16 - 28.83)	14.45***	(7.79 - 26.80)	14.64***	(9.39 - 22.80)
19	12.21***	(6.30 - 23.65)	33.42***	(17.17 - 65.05)	19.89***	(12.41 - 31.88)
Level of education completed						
Primary school or no schooling	1		1		1	
Junior Highschool	0.91*	(0.59 - 1.40)	0.73*	(0.46 - 1.15)	0.83*	(0.61 - 1.14)
Senior Highschool	0.71*	(0.45 - 1.12)	0.75*	(0.47 - 1.21)	0.7**	(0.51 - 0.98)
Working status						
Not working			1		1	
Student			1.4*	(0.90 - 2.18)	1.1*	(0.83 - 1.46)
Currently working			1.13*	(0.72 - 1.78)	0.92*	(0.67 - 1.27)
Still look for job			1.44*	(0.73 - 2.84)	1.45*	(0.87 - 2.40)
Nutritional status						
Normoweight			1		1	
Underweight			0.54**	(0.33 - 0.86)	0.66**	(0.47 - 0.95)
Overweight			2.02*	(0.84- 4.86)	1.58*	(0.98 - 2.55)
Obese			2.72*	(0.73- 10.13)	2.16**	(1.02 - 4.58)
Central obesity						
No			1			
Yes			1.71*	(0.67 - 4.35)		
Smoking behavior						
Never smoked					1	
Ever smoked					0.72*	(0.34 - 1.53)
Currently smoking					1.05*	(0.75 - 1.46)
Level of total cholesterol						
Normal (<200 mg/dl)					1	
High (>200 mg/dl)					1.14*	(0.67 - 1.93)
Level of LDL cholesterol						
Normal (<130 mg/dl)	1		1		1	
High (>=130 mg/dl)	1.48**	(1.01 - 2.16)	1.6*	(0.94 - 2.74)	1.4*	(0.88 - 2.22)

Abbreviations: LDL = low-density lipoprotein; HDL = high-density lipoprotein; aOR= adjusted Odds Ratio
Note: ***p<0.01; **p<0.05; *p<0.1

Table 4.
Multivariate Regression Analysis of Hypertension Risk Factors in Adolescents based on Riskesdas 2013

Characteristics	Girls		Boys		Overall	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
Hypertension						
Sex						
Girls					1	
Boys					1.16*	(0.64 - 2.12)
Age (years)						
15	1		1		1	
16	0.82*	(0.25 - 2.64)	1.75*	(0.40 - 7.67)	1.17*	(0.48 - 2.89)
17	1.19*	(0.43 - 3.32)	1.69*	(0.39 - 7.24)	1.45*	(0.63 - 3.37)
18	2.2*	(0.75 - 6.40)	4.92**	(1.15 - 21.00)	3.06**	(1.28 - 7.34)
19	0.9*	(0.23 - 3.49)	13.06***	(2.95 - 57.75)	3.25**	(1.25 - 8.41)
Level of education completed						
Primary school or no schooling	1		1		1	
Junior Highschool	1.15*	(0.46 - 2.87)	1.06*	(0.40 - 2.79)	1.16*	(0.60 - 2.26
Senior Highschool	1.72*	(0.62 - 4.80)	1.33*	(0.47 - 3.81)	1.47*	(0.70 - 3.10)
Working status						
Not working			1		1	
Student			1.34*	(0.51 - 3.52)	0.98*	(0.54 - 1.78)
Currently working			1.89*	(0.72- 4.94)	1.38*	(0.70 - 2.73)

Still look for job			1.77*	(0.42 - 7.30)	1.5*	(0.52 - 4.31)
Nutritional status						
Normoweight			1		1	
Underweight			0.25*	(0.06 - 1.10)	0.42*	(0.15 - 1.20)
Overweight			0.26*	(0.03 - 2.48)	1.32*	(0.51 - 3.38)
Obese			2.27*	(0.38 - 13.43)	5.69***	(2.20 - 14.8)
Central obesity						
No			1			
Yes			5.15**	(1.36 - 19.47)		
Smoking behavior						
Never smoked					1	
Ever smoked					0.51*	(0.07 - 3.88)
Currently smoking					1.18*	(0.58 - 2.40)
Level of total cholesterol						
Normal (<200 mg/dl)					1	
High (>200 mg/dl)					1.21*	(0.44 - 3.34)
Level of LDL cholesterol						
Normal (<130 mg/dl)	1		1		1	
High (>=130 mg/dl)	1.7*	(0.81 - 3.58)	3.15**	(1.31 - 7.56)	1.88*	(0.75 - 4.71)

Abbreviations: LDL = low-density lipoprotein; HDL = high-density lipoprotein; aOR = adjusted Odds Ratio
Note: ***p<0.01; **p<0.05; *p<0.1

DISCUSSION

Hypertension today is not just a health problem for adults, both in Indonesia and globally. Among all adolescents in this study, elevated blood pressure was already detected in the younger age group (15-19 years) with prehypertension and hypertension prevalence of 16.8% and 2.6%, respectively. When compared with the results of this study, a systematic review study showed a lower prevalence of pre-hypertension in adolescents globally, which was around 9.67%, at 10% in India, and 12.7% in Africa. [27–29] The prevalence obtained in this study is quite worrying, as almost 20% of Indonesian adolescents were already prehypertensive. Which is the strongest risk factor for hypertension.[30]

Early-stage hypertension is rarely showing symptoms; however, the increasing prevalence of obesity in children and adolescents, thus increasing the risk of developing hypertension at a younger age.[30] Ironically, blood pressure measurement in adolescents is rarely carried out because the impact of measuring status is not immediately visible, and tends to be ignored when compared to adults[31]. Meanwhile, the hypertension prevalence in Indonesian adolescents was similar to that reported in the US adolescents (2.7%) but smaller than global (4%), Indian (roughly 7%), and African (5.5%) adolescents as well as adolescents in low-middle-income countries (LIMCs) (9.8%) [27–29,32–34].

Variations in the prehypertension and hypertension prevalence in Indonesia and other countries may occur due to differences in subjects' characteristics or research methods. Cheung et al. (2017)A study in the US reported that hypertension prevalence varied among African-American, Hispanic, white, and Asian students, where African-Americans had the highest prevalence among the four ethnic groups[32]. In addition, differences in the methods used between studies, such as differences in the age range of the subjects reported. Other studies used a wider age range than this study, such as in Africa aged 2-19 years, India aged 4-19 years, globally aged 6-19 years, and India aged 10-19 years.[27–29,33] More prehypertension or hypertension status was likely to occur, which may eventually contribute to the higher reported prevalence. Differences in prevalence between countries can also be a result of differences in the sampling methods. The subjects in this study represent the national population because the sample design was intended for this purpose[16]; whereas the Indian and African meta-analyses involved subjects at the subnational level only.[28,33] Differences in how hypertension status is determined may also explain differences in the prevalence of hypertension across countries. This study measured adolescent blood pressure at least twice on one occasion/visit, while previous studies measured it on at least 3 separate occasions referring to The US 4th Report by the National High Blood Pressure Education Program (NHBPEP) Working Group. [27,29] Thus, the prevalence may vary between Indonesia and other countries due to the measurement method difference.

The study also showed that, across overall adolescents, older age was a risk factor for prehypertension and hypertension. It is similar to that reported by various studies where blood pressure increased rapidly with age and during puberty, which was more prevalent in boys than girls.[35–38] A study in China also found that adolescent puberty rates were associated with increased blood pressure. [36]

The primary outcome of this study is that obesity is a risk factor for hypertension in adolescents, which has been confirmed by various studies worldwide.[39–41] A systematic review summarized that the pathophysiology of hypertension in obese adolescents is complex. Several relevant factors included the endocrine system involving the renin-angiotensin-aldosterone system, corticosteroids and adiponectin, family history of hypertension, birth weight history, sleep patterns, and other clinical histories such as hyperuricemia.[12,42] Many studies and literature have reported obesity as one of the determinants of hypertension, and controlling adolescent obesity is one of the opportunities for intervention that can be implemented early.[43]

The results of the analysis of stratification by sex for prehypertension and hypertension were also presented in this study. The results show that older age, central obesity, and high LDL cholesterol were risk factors for hypertension in male adolescents, whereas there were no significant risk factors for hypertension in their female counterparts. A meta-analysis of 55 studies with a sample of 122,053 adolescents reported that the prevalence of increased blood pressure in males was 11.2% and occurred mostly in male adolescents in low-middle-income countries.[34] The sex-hypertension association is closely related to sex hormones, which have the potential impact on blood pressure. Estrogen inhibits the renin-angiotensin system causing a decrease in blood pressure. On the other hand, testosterone increases the renin-angiotensin system which makes blood pressure rise.[44,45]

Another risk factor found in this study related to hypertension in boys was central obesity. Previous studies showed that central obesity was a strong predictor of hypertension incidence[46] and a study in India reported that an abdominal circumference of 90 cm was associated with hypertension in adult males.[47] A study on Indonesian adolescents found that the average waist circumference of boys was higher than that of girls. In the study, the best cut-off value for the abdominal circumference to predict adolescent hypertension for <15 years of age was 90.1 cm; whereas, in adolescents of 15 years old the values were 103.5 cm and 104.85 cm to predict both systolic and diastolic hypertension.[48] Although the literature has provided this recommendation, the issue of central obesity in adolescents still has not received sufficient attention to prevent non-communicable diseases in the future.

As for LDL cholesterol, this study showed that it was a risk factor for hypertension in male adolescents as well as a risk factor for prehypertension in female adolescents. This result is in line with a literature review concluding that hypertensive adolescents had high LDL cholesterol levels.[49] The results of a study in Germany showed that among 5,629 boys with a median age of 10 years, boys with prehypertension (11.2%) were likely to have higher LDL cholesterol levels than the ones with normal blood pressure (8.2%).[50] The elevated total and LDL cholesterol are precursors of atherosclerosis that cause coronary heart disease in adulthood.[51] Based on this and other studies, screening and efforts to change health behaviors from adolescence are considered important to manage risk factors for future heart and vascular disease.

This study concluded that older adolescents and obesity were the risk factors for prehypertension and hypertension in adolescents. Older adolescents are in the stage of puberty which associates with an increase in blood pressure.[36] Many studies also reported that blood pressure increased rapidly with age and during puberty and it is experienced more by adolescent boys than girls.[35–38] A study in China also confirmed that obesity is the risk factor for hypertension in adolescents.[36,39,40] A systematic review explained complex hypertension pathophysiology in obese adolescents which is related to endocrine factors involving the renin-angiotensin-aldosterone system, corticosteroids, and adiponectin, family history of hypertension, history of birth weight, sleep pattern, and hyperuricemia.[12,42] Therefore, obese adolescents should be intervened immediately to prevent the development of hypertension in this vulnerable group.[43]

Results of analysis stratified by sex showed that older age, central obesity, and high LDL cholesterol were the risk factors for hypertension among adolescent boys; meanwhile, there were no significant risk factors in adolescent girls. This result is supported by a meta-analysis of 55 studies on 122.053 adolescents which concluded that the prevalence of elevated blood pressure in boys was 11.2% and mostly found in low- and middle-income countries (LMICs) adolescent boys.[34] Sex hormones have an important role in blood pressure, for example, estrogen can inhibit the renin-angiotensin system which causes a decrease in blood pressure whereas testosterone can increase the renin-angiotensin system leading to further increases in blood pressure.[44,45]

This study also found that central obesity was associated with hypertension among adolescent boys. A previous study in Brazil supported this finding which described central obesity as a strong predictor of hypertension incidence in adult males.[46] In addition, an Indian study also confirmed this result which reported waist circumference ≥90 cm had significantly related to hypertension among adult men.[47] Another study of Indonesian adolescents found that boys had higher waist circumferences compared to girls, suggesting a waist circumference of 90.1 cm as the best cut-off to predict hypertension among adolescents aged <15 years old; meanwhile waist circumference of 103.5 cm and 104.85 cm as the best cut off to predict hypertension among those who aged ≥15 years old [48]. Therefore, addressing obesity and the central obesity problem is an important priority to fight the continuous rise of hypertension in adolescents.

This study revealed that LDL cholesterol was the risk factor for hypertension among adolescent boys and girls. A literature review confirmed this result which reported that higher LDL cholesterol was found in hypertension adolescents.[49] As previously discussed, a study in Germany on pre-hypertensive teenage boys had also detected a tendency for LDL cholesterol to be higher than normotensive ones[50]. Elevated total cholesterol and LDL is atherosclerosis precursor that leads to coronary heart diseases in adulthood.[51] These pieces of evidence emphasize the need to detect hypertension risk factors early and practice a healthy lifestyle since childhood. Hence, healthy lifestyle interventions such as healthy eating behavior, physical activity, and regular blood pressure monitoring should be a national strategy to control prehypertension and hypertension among adolescents.[35]

Currently, health services for school-aged children and adolescents are one of the key performance indicators of the Indonesian Ministry of Health that has been implemented through the school health promotion (SHP) and adolescent-friendly health service (AFHS) program.[52] In AFHS, health services related to non-communicable diseases (NCD) prevention including activities on early detection through the family history of the disease, blood pressure measurement, blood sugar, and cholesterol tests, providing communication and education about balanced nutrition and obesity prevention, counseling and case referrals if found more than one risk factor for NCDs. Meanwhile, SHP activities included anthropometric measurements and nutritional status evaluation, as well as physical activities through stretching exercises together at school.[53,54]

In addition, integrated healthcare posts (IHP) for adolescent in each hamlet has been promoted since 2018 to increase access and coverage of adolescent health services, such as anthropometric measurements and blood pressure.[55] This policy was strengthened by the national action plan to improve the welfare of school-aged children and adolescents in 2022 which involves multi-sectors to manage intervention in reducing poor diet, anemia, malnutrition, and obesity among school-aged and adolescents.[56]

Early detection of NCDs program by the government is currently for the adult population aged 15 years and older, meaning that national evaluation for NCDs has not reached the young adolescent group yet.[52] Although the NCDs early detection is already part of activities in SHP and AFHS, national data related to specific NCDs among adolescents is still limited.[53] Data in Indonesia's health profile 2020 is still limited to school units, including the percentage of schools receiving student health services, 81.9% for junior high school, and 79.1% for senior high school.[54] Therefore, this study suggests the importance of national policy for early detection, diagnosis, monitoring, and evaluation of hypertension and its risk factors among school-aged children and adolescents.

This study has limitations. The cross-sectional design used in this study is only able to describe prevalence variation and correlation among factors related to hypertension, not causality. In addition, the method of blood pressure measurement differs from the global guidelines, allowing for potential bias in hypertension determination. The relationship between hypertension and puberty, sodium intake, food consumption, and family history of hypertension were not able to explore in this study due to limited data. The prevalence of prehypertension and hypertension in this study did not involve young adolescents aged 10-14 years, thus it may lead to data underreporting. Despite these limitations, this study has the strength of a large sample size that represents the national population, hence, the prevalence of prehypertension and hypertension among adolescents can accurately reflect the condition of the Indonesian adolescent population.

CONCLUSION

This study revealed that almost 3% of adolescents have hypertension whilst prehypertension has been detected in nearly one-fifth of adolescents which was higher in boys than girls. Different risk factors for prehypertension and hypertension in adolescent boys and girls were also detected. Older age and high levels of LDL cholesterol were risk factors in prehypertension adolescent girls. Risk factors of hypertension among adolescent boys were older age, central obesity, and high LDL cholesterol. Addressing prehypertension and hypertension should be a government priority to prevent and control NCDs among adolescents. Regular measurement of blood pressure, blood cholesterol, and anthropometry are critical to detect, diagnose, and monitoring early the risk factors of hypertension during adolescence.

Contributorship statement SS, PPA, RM and RR were responsible for the conception of this study and for methods development. RM analysed data. TP, RM and RR prepared the first draft. SS is responsible for the overall content as a guarantor. SS, RM, PPA, RR, and TP have read and approved the content in this manuscript.

Competing interests. All manuscript contributors declare no conflict of interest.

Funding. The authors received no financial support for the research, authorship, and/or publication of this article.

Data sharing statement All data generated or analyzed during this study are included in this published article and its supplementary files. The data that support the findings of this study are available from the Data Management Laboratory of the National Institute of Health Research and Development (NIHRD), Ministry of Health of Indonesia. Data can be made available after approval of a written request to the Data Management Laboratory—NIHRD at mandat@litbang.depkes.go.id/labmandat.litbangkes@gmail.com.

Ethics approval

The implementation of Riskesdas in 2013, has obtained ethical approval from the Health Research Ethics Commission (KEPK), the Health Research and Development Agency of the Ministry of Health of the Republic of Indonesia with the number: LB.02.01/5.2/KE.006/2013. All respondents gave written consent after being given an explanation and before data collection was carried out. Health research ethical guidelines have been followed including consent, voluntary participation, confidentiality, and anonymity.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	*N/A*
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	19
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	29
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-29
Generalisability	21	Discuss the generalisability (external validity) of the study results	N/A
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	30

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.