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Prevalence and associated factors for prehypertension and hypertension among Indonesian adolescents: a cross-sectional community survey

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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 analysed 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 prehypertension in adolescents was 16.8% and hypertension was 2.6%. In all adolescents, the risk factors for prehypertension were boys (adjusted OR, aOR 1.48; 95% CI 1.10 to 1.97), 18 years old (aOR 14.64; 95% CI 9.39 to 22.80), and 19 years old (aOR 19.89; 95% CI 12.41 to 31.88), and obese (aOR 2.16; 95% CI 1.02 to 4.58). Risk factors for hypertension in all adolescents included the age of 18 years old (aOR 3.06; 95% CI 1.28 to 7.34) and 19 years (aOR 3.25; 95% CI 1.25 to 8.41) and obesity (aOR 5.69; 95% CI 2.20 to 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 programmes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The data on prehypertension and hypertension in adolescents that we presented may enrich the evidence base of non-communicable disease 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 acknowledgement.
⇒ Several independent variables were also based on measurement results, such as body mass index, 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 (SBP) 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 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 min 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 and cardiovascular.[9] Data on prehypertension at 40 years of age and older in Indonesia in the year 2014 were around 32.5%.[10]

A systematic review of 50 cohort studies from the USA, 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% 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 programmes 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 2966. After data checking of the outliers of height, weight and several variables, as well as the completeness of the data, the number of samples analysed remained around 2735. Based on our study's findings, which showed that the proportion of prehypertension in the normoweight group was 16.2% and the adjusted OR (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 OR.[14]

Measurements

The data collected in this study included demographic characteristics, health conditions of NCDs and health-related behaviour. Data were collected through face-to-face interviews by trained enumerators with 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. First, data were collected and recorded on a paper questionnaire and then entered into the data entry programme 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 30 min 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 min 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 two times. If the result of the second measurement was different by 10mm Hg compared with 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 0.1kg. 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 2 m and an accuracy of 0.1 cm.[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 analysed 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, low-density lipoprotein cholesterol (LDL-C), Trigl) with colorimetric enzymatic principles for several tests, namely total cholesterol, HDL, direct LDL, triglycerides (TG) 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 10min continuously. The number of active days in the week and the duration of the activity will be converted into metabolic equivalents (METs). For heavy activity or heavy exercise, it weighed eight times. While moderate activity or moderate exercise weighed four times and light activity weighed two times. Subjects were categorised as less active if they have a total activity of less than 600 METs 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 categorised as 'enough' if the subject consumed fruit and/or vegetables in at least five portions per day for 7days a week. Then it would be categorised as 'less' if the consumption of vegetables and/or fruit was less than five portions per day for 7days 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 programmes and the collection of biomedical specimens. The trials were carried out in collaboration between researchers, academics (from three universities in Indonesia) and professional organisations. 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 categorised as prehypertension if the average 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 categorised if the SBP value was greater than 120–139mm Hg and/or if the DBP was greater than 80–89mm Hg. Whereas, hypertension for subjects aged 18–19 years was determined by an SBP greater than or equal to 140mm Hg and/or DBP greater than or equal to 90mm Hg (according to JNC VII).[20]

Independent variables

The independent variables consisted of individual characteristics, gender, marital status, age, occupation, education level, residency, smoking behaviour, physical activity, fruit and vegetable eating habits, fatty/fried food habits, body mass index (BMI) and lipid profile. Then those were categorised 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, LDL cholesterol (Chol-LDL), 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 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 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 two 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 BMI calculation. To assess nutritional status using the BAZ indicator, the weight and height values of each subject were converted into standardised 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), normoweight (BAZ >=-2 SD sd +1 SD), overweight (BAZ >1 SD to 2 SD), obese (BAZ > 2 SD). Analysis of the conversion of weight and height into BMI (nutritional status) using the formula of weight (metres) divided by height squared (m^2) then categorised based on the BMI category according to WHO (2000), namely: underweight (BMI<18.5 kg/m^2), good/normoweight (BMI=18.5–24,9 kg/m^2), 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 years 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 organised and carried out by the research team. Data management consisted of a series of activities starting from the development of data entry programmes, the process of sending and receiving data from the enumerator to the central data team, editing, coding and data cleaning. Data amputation has also been performed on variables that require it. Furthermore, the data are ready to be analysed. Data entry has been conducted at the research location by the enumerator using the CS Pro-based data entry programme.[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 χ^2 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 OR was used as a measure of association. A stepwise process with backward elimination and a rejection criterion of the p>0.05 was used to create a final explanatory model with a subset and relative OR of the components associated with hypertension. All analyses were performed using Stata S.E. V.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 2725 individuals, 1416 were female and 1319 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 Chol-LDL levels (≥130 mg/dL) reached 13.8%, had high TG levels (≥150 g/dL) at around 12.2% and with low Chol-HDL levels (<40 mg/dL) reached 24.6%. In this study, the proportion of students with hypertension was 2.6% and prehypertension 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 behaviour, total cholesterol level, Chol-LDL level, Chol-HDL 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 with 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

Table 1 Sociodemographic and health-related characteristics of 2735 participants in the 2013 Riskesdas, in total and by gender

Characteristics	Girls		Boys		P value	Total	
	n=**1416**	%	n=**1319**	%		n=**2735**	%
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	1282	90.5	1296	98.3		2578	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		1336	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		1355	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		1431	52.3
Urban	678	47.9	626	47.5		1304	47.7
Nutritional status					<0.001		
Normoweight	114	8.1	192	14.6		306	11.2
Underweight	1174	82.9	1031	78.2		2205	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	1207	85.2	1239	93.9		2446	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	1287	90.9	1012	76.7		2299	84.1
Smoking behaviour					<0.001		
Never smoked	1405	99.2	682	51.7		2087	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		1377	50.4
Everyday	579	40.9	531	40.3		1110	40.6
Fruits and vegetables consumption					0.116		
Sufficient/enough	19	1.3	28	2.1		47	1.7
Insufficient/less	1397	98.7	1291	97.9		2688	98.3

Continued

Table 1 Continued

Characteristics	Girls n=1416	%	Boys n=1319	%	P value	Total n=2735	%
Level of total cholesterol					<0.001		
Normal (<200 mg/dL)	1206	85.2	1245	94.4		2451	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)	1150	81.2	1209	91.7		2359	86.3
High (≥130 mg/dL)	266	18.8	110	8.3		376	13.8
Level of triglycerides					0.354		
Normal (<150 mg/dL)	1251	88.4	1150	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)	1191	84.1	870	66		2061	75.4
Low (<40 mg/dL)	225	15.9	449	34		674	24.6
Hypertension					0.02		
Normotensive	1169	82.6	1036	78.5		2205	80.6
Prehypertensive	210	14.8	248	18.8		458	16.8
Hypertensive	37	2.6	35	2.7		72	2.6

HDL, high-density lipoprotein; LDL, low-density lipoprotein.

central obesity than boys. Girls were less physically active than boys. Boys were more likely than girls to engage in smoking behaviour. High levels of total cholesterol and Chol-LDL were more common in girls. While low HDL levels were more common in boys than girls. Prehypertension was higher in boys than girls, but the prevalence of hypertension did not differ between girls and boys (table 1).

Bivariate analysis

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

Risk factors associated with prehypertension and hypertension among adolescents

Multivariate analysis showed the risk factors for prehypertension in all adolescents and by gender (table 3). In all adolescents, the risk factors for prehypertension were boys (aOR 1.48, 95% CI 1.10 to 1.97), at the age of 18 years old (aOR 14.64, 95% CI 9.39 to 22.80), and 19 years old (aOR 19.89, 95% CI 12.41 to 31.88), and obese (aOR 2.16, 95% CI 1.02 to 4.58). Whereas in girls, the chance of developing prehypertension increases with increasing age and Chol-LDL levels. At the age of 18 years and 19 years, the risk for developing prehypertension was 15.33 times (95% CI 8.16 to 28.83) and 12.21 times (95% CI 6.30 to 23.65) higher when compared with the age of 15 years. Adolescent girls who have a high Chol-LDL level (≥130 mg/dL) had a relative risk of prehypertension around 1.48 times (95% CI 1.01 to 2.16) higher than those with normal Chol-LDL levels. Data analysis on boys showed that age was also a risk factor for prehypertension where at the age of 18 years and 19 years old the risk was 14.45 times (95% CI 7.79 to 26.80) and 33.42 times (95% CI 17.17 to 65.05) higher if compared with 15 years of age. In addition, there were also found protective factors against prehypertension including the age of 16 years (aOR 0.21, 95% CI 0.006 to 0.72) and underweight (aOR 0.54, 95% CI 0.33 to 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 to 7.34) and 19 years (aOR 3.25 95% CI 1.25 to 8.41) and obesity (aOR 5.69 95% CI 2.20 to 14.8). Some factors showed a lower risk of prehypertension, which were high school graduates (aOR 0.70 95% CI 0.51 to 0.98) and underweight (aOR 0.66 95% CI 0.47 to 0.95). Meanwhile, several risk factors for hypertension in boys were age, central obesity and Chol-LDL 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 to

Table 2 Factors associated to hypertension and prehypertension in adolescents based on Riskesdas 2013, according to sociodemographic and health characteristics

Characteristics	Girls		Boys		Overall	
	Prehypertension n (%)	Hypertension n (%)	Prehypertension n (%)	Hypertension n (%)	Prehypertension 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 behaviour		*		***		***
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)

Continued

Table 2 Continued

Characteristics	Girls		Boys		Overall	
	Prehypertension n (%)	Hypertension n (%)	Prehypertension n (%)	Hypertension n (%)	Prehypertension n (%)	Hypertension n (%)
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)

*p<0.05, **p<0.01, ***p<0.001.
HDL, high-density lipoprotein; LDL, low-density lipoprotein.

21.00) and at 19 years the risk was 13.06 times (95% CI 2.95 to 57.75) higher than at the age of 15 years. Boys who were centrally obese had 5.15 times (95% CI 1.36 to 19.47) higher risk of hypertension than those who were not centrally obese. In addition, boys with a high level of Chol-LDL (≥130 mg/dL) had 3.15 times (95% CI 1.31 to 7.56) higher risk than those with normal Chol-LDL levels for hypertension.

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 prehypertension 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, obesity has been on the rise among children and adolescents nowadays, 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 with 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-income and middle-income countries (LMICs) (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* 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] Meanwhile, 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 three separate occasions referring to The US fourth Report by the National High Blood Pressure Education Programme Working Group.[27 29]

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

Table 3 Multivariate regression analysis of prehypertension risk factors in adolescents based on Riskesdas 2013

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

*p<0.05, **p<0.01, ***p<0.001.
aOR, adjusted OR; LDL, low-density lipoprotein.

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 summarised 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, birthweight history, sleep patterns and other clinical histories such as hyperuricaemia.[12 42] Many studies and

Table 4 Multivariate regression analysis of hypertension risk factors in adolescents based on Riskesdas 2013

	Girls		Boys		Overall	
Characteristics	aOR	95% CI	aOR	95% CI	aOR	95% CI
Hypertension						
Sex						
Girls					1	
Boys					1.16*	(0.64 to 2.12)
Age (years)						
15	1		1		1	
16	0.82*	(0.25 to 2.64)	1.75*	(0.40 to 7.67)	1.17*	(0.48 to 2.89)
17	1.19*	(0.43 to 3.32)	1.69*	(0.39 to 7.24)	1.45*	(0.63 to 3.37)
18	2.2*	(0.75 to 6.40)	4.92**	(1.15 to 21.00)	3.06**	(1.28 to 7.34)
19	0.9*	(0.23 to 3.49)	13.06***	(2.95 to 57.75)	3.25**	(1.25 to 8.41)
Level of education completed						
Primary school or no schooling	1		1		1	
Junior highschool	1.15*	(0.46 to 2.87)	1.06*	(0.40 to 2.79)	1.16*	(0.60 to 2.26
Senior highschool	1.72*	(0.62 to 4.80)	1.33*	(0.47 to 3.81)	1.47*	(0.70 to 3.10)
Working status						
Not working			1		1	
Student			1.34*	(0.51 to 3.52)	0.98*	(0.54 to 1.78)
Currently working			1.89*	(0.72 to 4.94)	1.38*	(0.70 to 2.73)
Still look for job			1.77*	(0.42 to 7.30)	1.5*	(0.52 to 4.31)
Nutritional status						
Normoweight			1		1	
Underweight			0.25*	(0.06 to 1.10)	0.42*	(0.15 to 1.20)
Overweight			0.26*	(0.03 to 2.48)	1.32*	(0.51 to 3.38)
Obese			2.27*	(0.38 to 13.43)	5.69***	(2.20 to 14.8)
Central obesity						
No			1			
Yes			5.15**	(1.36 to 19.47)		
Smoking behaviour						
Never smoked					1	
Ever smoked					0.51*	(0.07 to 3.88)
Currently smoking					1.18*	(0.58 to 2.40)
Level of total cholesterol						
Normal (<200 mg/dL)					1	
High (>200 mg/dL)					1.21*	(0.44 to 3.34)
Level of LDL cholesterol						
Normal (<130 mg/dL)	1		1		1	
High (≥130 mg/dL)	1.7*	(0.81 to 3.58)	3.15**	(1.31 to 7.56)	1.88*	(0.75 to 4.71)

*p<0.05, **p<0.01, ***p<0.001.
aOR, adjusted OR; LDL, low-density lipoprotein.

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 Chol-LDL 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 LMICs.[34] The sex–hypertension association is closely related to sex hormones, which have the potential impact on blood pressure. Oestrogen 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 NCDs in the future.

As for Chol-LDL, 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 Chol-LDL levels.[49] The results of a study in Germany showed that among 5629 boys with a median age of 10 years, boys with prehypertension (11.2%) were likely to have higher Chol-LDL levels than the ones with normal blood pressure (8.2%).[50] The elevated total and Chol-LDL are precursors of atherosclerosis that cause coronary heart disease in adulthood.[51] Based on this and other studies, screening and efforts to change health behaviours from adolescence are considered important to manage risk factors for future heart and vascular disease.

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) programme.[52] In AFHS, health services related to NCDs 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, counselling 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 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 multisectors to manage intervention in reducing poor diet, anaemia, malnutrition and obesity among school aged and adolescents.[56]

Early detection of NCDs programme 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 are 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 while 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 Chol-LDL were risk factors in prehypertension adolescent girls. Risk factors of hypertension among adolescent boys were older age, central obesity and high Chol-LDL. 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.

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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.

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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. Participants gave informed consent to participate in the study before taking part.

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REFERENCES

1 World Health Organization. Noncommunicable diseases; 2021. Available: www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases
2 World Health Organization. *Noncommunicable diseases: progress monitor 2020*. Geneva PP - Geneva: World Health Organization, 2020: 1–224.
3 Akseer N, Mehta S, Wigle J, *et al*. Non-communicable diseases among adolescents: current status, determinants, interventions and policies. *BMC Public Health* 2020;20:1908.
4 National Institute of Health Research and Development Ministry of Health of Indonesia. In: *Riset Kesehatan Dasar (RISKESDAS) 2007: National Report*. Central Jakarta, 2008.
5 Health Research and Development Agency, World Health Organization, US Centers for Disease Control and Prevention. In: *Global School-Based Student Health Survey (GSHS) Indonesia 2015*. Jakarta, 2015.
6 Indonesia Ministry of Health, Ministry of Education, The World Health Organization, *et al*. In: *Global School-Based Student Health Survey (GSHS) Indonesia 2007*. Jakarta, 2007.
7 National Institute of Health Research and Development Ministry of Health of Indonesia. *Total diet study: individual food consumption survey indonesia 2014*. Jakarta, 2014.
8 Pall D, Katona E, Zrinyi M, *et al*. Screening of adolescent hypertension, and evaluation of target organ damages. results from the debrecen hypertension study. *American Journal of Hypertension* 2005;18:A113.
9 Guo X, Zhang X, Guo L, *et al*. Association between pre-hypertension and cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Curr Hypertens Rep* 2013;15:703–16.
10 Lydia A, Setiati S, Soejono CH, *et al*. Prevalence of prehypertension and its risk factors in midlife and late life: Indonesian family life survey 2014-2015. *BMC Public Health* 2021;21:493.
11 Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood. *Circulation* 2008;117:3171–80.
12 Ewald DR, Haldeman PhD LA. Risk factors in adolescent hypertension. *Glob Pediatr Health* 2016;3:2333794X15625159.
13 Sakti NW. Take advantage of demographic bonus opportunities. 2017.
14 Lwanga SK, Lemeshow S. *The world health organization. sample size determination in health studies: a practical manual*. Geneva PP - Geneva: World Health Organization, 1991: 80.
15 National Institute of Health Research, of Health of Indonesia DM. Indonesia basic health research (riskesdas) 2013 report. Jakarta, Available: https://www.litbang.kemkes.go.id/laporan-riset-kesehatan-dasar-riskesdas/
16 National Institute of Health Research and Development Ministry of Health of Indonesia. *Basic health research (riskesdas)*. Jakarta, 2013.
17 National Institute of Health Research and Development Ministry of Health of Indonesia. *Biomedical indonesia basic health survey*. Jakarta, 2013.
18 World Health Organization. *Noncommunicable diseases and mental health cluster. WHO STEPS surveillance manual: the WHO stepwise approach to chronic disease risk factor surveillance*. Geneva: World Health Organization, 2005: 1–490.
19 U.S. Department of Health and Human Service. *The forth report on the: diagnosis, evaluation, and treatment of high blood pressure in children and adolescents*. Forth edit. Bethesda: NIH Publication, 2005.
20 U.S. Department of Health and Human Service. The seventh report of the joint national committee on: prevention, detection, evaluation, and treatment of high blood pressure. Bethesda, 2004.
21 Grundy SM, Becker D, Clark LT, *et al*. Detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). *Circulation* 2002;106:3143–421.
22 Jellinger PS, Handelsman Y, Rosenblit PD, *et al*. AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS AND AMERICAN COLLEGE OF ENDOCRINOLOGY GUIDELINES FOR MANAGEMENT OF DYSLIPIDEMIA AND PREVENTION OF CARDIOVASCULAR DISEASE. *Endocr Pract* 2017;23(Suppl 2):1–87.
23 WHO Consultation on Obesity. Obesity: preventing and managing the global epidemic: report of a WHO consultation. Geneva PP - Geneva World Health Organization; 1999. 1–252.
24 Xi B, Zong X, Kelishadi R, *et al*. International waist circumference percentile cutoffs for central obesity in children and adolescents aged 6 to 18 years. *J Clin Endocrinol Metab* 2020;105:e1569–83.
25 Alberti K, Zimmet P, Shaw J, *et al*. The metabolic syndrome--a new worldwide definition. *Lancet* 2005;366:1059–62.
26 National Institute Health Research and Development. *National basic health survey data management guidelines 2013*. Jakarta, 2013.
27 Meena J, Singh M, Agarwal A, *et al*. Prevalence of hypertension among children and adolescents in India: a systematic review and meta-analysis. *Indian J Pediatr* 2021;88:1107–14.
28 Noubiap JJ, Essouma M, Bigna JJ, *et al*. Prevalence of elevated blood pressure in children and adolescents in africa: a systematic review and meta-analysis. *Lancet Public Health* 2017;2:e375–86.
29 Song P, Zhang Y, Yu J, *et al*. Global prevalence of hypertension in children: a systematic review and meta-analysis. *JAMA Pediatr* 2019;173:1154–63.
30 Olsen MH, Angell SY, Asma S, *et al*. A call to action and A lifecourse strategy to address the global burden of raised blood pressure on current and future generations: the lancet commission on hypertension. *Lancet* 2016;388:2665–712.
31 Magalhães M de A, Farah BQ, Barros M de, *et al*. Previous blood pressure measurement and associated factors in student adolescents. *Einstein (Sao Paulo)* 2015;13:381–7.
32 Cheung EL, Bell CS, Samuel JP, *et al*. Race and obesity in adolescent hypertension. *Pediatrics* 2017;139:e20161433.
33 Daniel RA, Haldar P, Prasad M, *et al*. Prevalence of hypertension among adolescents (10-19 years) in India: a systematic review and meta-analysis of cross-sectional studies. *PLoS One* 2020;15:e0239929.
34 de Moraes ACF, Lacerda MB, Moreno LA, *et al*. Prevalence of high blood pressure in 122,053 adolescents: a systematic review and meta-regression. *Medicine (Baltimore)* 2014;93:e232.
35 Chen C, Yuan Z. Prevalence and risk factors for prehypertension and hypertension among adults in central China from 2000-2011. *Clin Exp Hypertens* 2018;40:734–43.
36 Li Y, Dong Y, Zou Z, *et al*. Association between pubertal development and elevated blood pressure in children. *J Clin Hypertens (Greenwich)* 2021;23:1498–505.
37 Siklar Z, Berberoglu M, Savas Erdeve S, *et al*. Contribution of clinical, metabolic, and genetic factors on hypertension in obese children and adolescents. *J Pediatr Endocrinol Metab* 2011;24:21–4.
38 Tu W, Eckert GJ, Saha C, *et al*. Synchronization of adolescent blood pressure and pubertal somatic growth. *J Clin Endocrinol Metab* 2009;94:5019–22.

39 Fan Z, Liao Z, Zong X, *et al*. Differences in prevalence of prehypertension and hypertension in children and adolescents in the eastern, central and Western regions of China from 1991-2011 and the associated risk factors. *PLoS One* 2019;14:e0210591.
40 Liang X, Xiao L, Luo Y, *et al*. Prevalence and risk factors of childhood hypertension from birth through childhood: a retrospective cohort study. *J Hum Hypertens* 2020;34:151–64.
41 Liu K, Li C, Gong H, *et al*. Prevalence and risk factors for hypertension in adolescents aged 12 to 17 years: a school-based study in China. *Hypertension* 2021;78:1577–85.
42 Wirix AJG, Kaspers PJ, Nauta J, *et al*. Pathophysiology of hypertension in obese children: a systematic review. *Obes Rev* 2015;16:831–42.
43 Azegami T, Uchida K, Tokumura M, *et al*. Blood pressure tracking from childhood to adulthood. *Front Pediatr* 2021;9:785356.
44 Colafella KMM, Denton KM. Sex-Specific differences in hypertension and associated cardiovascular disease. *Nat Rev Nephrol* 2018;14:185–201.
45 dos Santos RL, da Silva FB, Ribeiro RF, *et al*. Sex hormones in the cardiovascular system. *Horm Mol Biol Clin Investig* 2014;18:89–103.
46 Fuchs FD, Gus M, Moreira LB, *et al*. Anthropometric indices and the incidence of hypertension: a comparative analysis. *Obes Res* 2005;13:1515–7.
47 Kumar C, Kiran K, Sagar V, *et al*. Association of hypertension with obesity among adults in a rural population of jharkhand. *Int J Med Sci Public Health* 2016;5:2545.
48 Alamanda E, Prawirohartono EP, Mulyani NS. Predicting hypertension using waist circumference in obese indonesian adolescents. *PI* 2010;50:300.
49 Kelly RK, Magnussen CG, Sabin MA, *et al*. Development of hypertension in overweight adolescents: a review. *Adolesc Health Med Ther* 2015;6:171–87.
50 Haas GM, Bertsch T, Schwandt P. Prehypertension and cardiovascular risk factors in children and adolescents participating in the community-based prevention education program family heart study. *Int J Prev Med* 2014;5(Suppl 1):S50–6.
51 Lozano P, Henrikson NB, Morrison CC, *et al*. Lipid screening in childhood and adolescence for detection of multifactorial dyslipidemia: evidence report and systematic review for the US preventive services Task force. *JAMA* 2016;316:634–44.
52 Action plan for activities of the directorate of family health for 2020-2024. Jakarta, Available: https://kesga.kemkes.go.id/assets/file/pedoman/RAKKESGA%20TAHUN%202020-2024.pdf"><a href="https://kesga.kemkes.go.id/assets/file/pedoman/RAKKESGA" tahun="" 2020-2024.pdf="">https://kesga.kemkes.go.id/assets/file/pedoman/RAKKESGA TAHUN 2020-2024.pdf
53 Ministry of Health of Indonesia. Regulation of the minister of health regarding child health efforts. Number 25 Indonesia,
54 Ministry of Health of Indonesia. *Technical guidelines for the implementation of healthy schools/madrasahs*. Jakarta: Ministry of Health of Republic Indonesia, 2021: 1–144.
55 Ministry of Health of Indonesia. *Technical guidelines for the implementation of adolescent health services (posyandu remaja)*. Jakarta: Ministry of Health of Republic Indonesia, 2018: 1–128.
56 Coordinating Ministry for Human Development and Culture of the Republic of Indonesia. Regulation of the coordinating minister for human development and culture of the republic of indonesia regarding the national action plan for improving the welfare of school-age children and adolescents. Number 1 Indonesia, 2022.