Blood pressure levels among children in rural Uganda: results from 1,913 children in a general population survey

(Childhood elevated blood pressure, Uganda)

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SUMMARY TABLE

What is known about this topic	• In 2008, the WHO reported that Africa had the highest prevalence of raised blood pressure globally among individuals older than 25 years. • Children with elevated blood pressure over prolonged periods of time are considered to be at higher risk of having hypertension as adults • Currently there are very few studies reporting hypertension prevalence/ prevalence of elevated blood pressure among children in rural Uganda and rural sub-Saharan Africa at large.
What this study adds	• This study finds a high prevalence of consistently elevated blood pressure over time among children in rural Uganda despite high levels of stunting and being underweight. Thus, the study provides more insight on the origin of the high levels of hypertension reported among adults in rural Uganda and possibly other sub-Saharan African countries. • This study also emphasises the need for multiple measurements in assessing hypertension among children and young adolescents, whilst acknowledging the lack of standard reference blood pressure values inclusive of children in rural African settings.

ABSTRACT

Despite increasing levels of adult hypertension in sub-Saharan Africa (SSA), there is limited information on elevated blood pressure among children in SSA. We described the distribution of blood pressure among children in rural Uganda and estimated hypertension prevalence. We conducted a cross-sectional study in south-western Uganda, collecting demographic, anthropometric and blood pressure measurements from children aged 6-12 years. Children with elevated blood pressure (systolic and/or diastolic blood pressure greater or equal to the 95th percentile for age, height and sex) were invited for two further assessments 6-18 months later. We described blood pressure distribution at first assessment, assessed associations with demographic and anthropometric characteristics and estimated prevalence of hypertension as defined by having elevated blood pressure on three separate occasions months apart. Blood pressure (BP) was measured in 1913 children (50% male, 3% overweight or obese, 22% stunted) at the first assessment. Mean (SD) systolic and diastolic BP at first assessment was 113.4mmHg (±10.8) and 69.5mmHg (±8.3), respectively, and 44.2% had elevated BP. Older age, higher BMI, and being female were associated with higher BP, and stunted height was associated with lower BP. An estimated 7.8% [95% CI:(6.6 - 9.1)], (males: 6.8%, females: 9.0%), had elevated BP on three separate occasions, and were considered hypertensive. High blood pressure levels among adults in SSA may be set early in life. In this study, obesity (a common lifestyle modifiable risk factor in other settings) was largely irrelevant. More research is needed to understand the main drivers for elevated blood pressure in SSA further.

INTRODUCTION

Hypertension is the most common modifiable risk factor for cardiovascular disease worldwide affecting 1.13 billion people and estimated to cause 12.8% of all deaths (1, 2). Individuals living with hypertension are three times more likely to have cardiovascular disease and twice as likely to die from cardiovascular diseases than individuals with normal blood pressure (3). In 2008, the WHO reported that Africa had the highest prevalence of raised blood pressure among individuals older than 25 years, estimated at 46% (2). In Uganda, over 35% of the population over the age of 30 years is estimated to have hypertension and this percentage is expected to increase as a result of dietary, lifestyle and socio-economic changes (4).

Exposures such as nutrition, physical activity, smoking, alcohol use, and being overweight or obese have been found to be strongly associated with increased blood pressure in adulthood and explain much of the burden of hypertension in higher-income countries. However, much less is known about the causes of elevated blood pressure in low-income settings, such as Uganda, where Western life-style risk factors are not as common yet blood pressure levels are high.

Children with elevated blood pressure over prolonged periods of time are considered to be at higher risk of having hypertension as adults (5-7). Despite hypertension being widely studied in adults, little is known about this problem in children in most sub-Saharan African (SSA) countries. In 2017, a systematic review conducted among children in Africa, considered 51 studies, identifying seven from East Africa, with six of these from only one country (Seychelles) (8). This review estimated 12.7% of African children had pre-hypertension and 5.5% had hypertension (8).

In Uganda the prevalence of hypertension in children from a semi-urban setting in 2010 was estimated to be 3.8% (9), however, studies from other parts of Africa suggest that this is likely to differ in rural settings, with some suggesting a higher prevalence and others a lower prevalence (5, 8). Currently there is limited information regarding elevated blood pressure among children in rural Uganda.

Using the widely recognised definition of hypertension by the National High Blood Pressure Education Programme (NHBPEP) in the US, a child is defined as suffering from hypertension if on three separate occasions their systolic or diastolic blood pressure is greater than or equal to the 95th percentile of the normative distribution of blood pressure for their sex, age, and height (10). However, the internationally recognised nomograms most widely used reference a normative distribution derived from a US population of 63,227 children aged 1-17 years of varying ethnicity (black (29%), Hispanic (10%), white (54%), Asian (3%), native American (1%) and other (3%)) (10). By contrast, very limited information exists on blood pressure normative distributions in children from sub-Saharan African populations. The distribution of blood pressure among children in rural Africa may differ from children of equivalent age, sex and height in the United States as a result of different genetic factors, lifestyles, nutrition, increased perceived stress and other environmental factors that influence blood pressure (8, 9, 11, 12).

Using data collected in 2016-2017 from a rural population-based cohort in central Uganda, we aimed to: (i) describe levels of blood pressure among children aged 6-12 years in this population (ii) assess associations with sex, age and anthropometric characteristics (BMI and stunting), and (iii) determine the prevalence of hypertension (based on three separate, consecutive measurement occasions and internationally recognised nomograms) among children in this setting.

MATERIALS AND METHODS

Study design

We conducted a cross sectional study to measure blood pressure in children aged 6-12 years. Children identified as having elevated blood pressure in the initial cross sectional assessment were followed up for further assessments.

The study was nested in the General Population Cohort (GPC). This is a rural population-based cohort of over 22,000 people living within the Kyamulibwa sub-county of Kalungu District in rural south-western Uganda. The cohort was established in 1989 by the Medical Research Council (MRC)/ Uganda Virus Research Institute (UVRI) Uganda Research Unit on AIDS. Full details of the GPC can be found elsewhere (13).

The cohort comprises residents of 25 rural villages, not far from Lake Victoria. Typical of many rural communities in Uganda, 50% of the population is under the age of 15 years. Participants are mostly involved in small-scale farming, literacy levels are comparatively low, and the main income-earning activity is trading in bananas, coffee, beans, and fish. All households within the cohort are routinely visited and mapped in an annual census conducted by MRC/UVRI survey teams (14).

Seventeen of the 25 villages in the cohort were randomly selected for this study. All children in the selected villages aged 6-12 years were eligible and invited to participate in the study through a door to door census. Blood pressure measurements were conducted at a centralised location 10-14 days later by study nurses who also collected baseline demographic and anthropometric data. These activities were carried out between March and November 2016.

Ethical approval for the study was obtained from the Uganda Virus Research Institute Ethics Committee and the Uganda National Council for Science and Technology. Written informed consent and assent was obtained from parents/ guardians and children respectively in English or the local language.

Measurements

Weight and height measurements were taken using calibrated Seca scales and stadiometers. Children whose height for age Z-score (calculated using the WHO Child Growth Standards Stata program (15)) was more than two standard deviations below the WHO Child Growth Standards median were classified as stunted (16). Children were considered as underweight, normal weight, overweight or obese based on their BMI for age percentiles in reference to the WHO Child Growth Standards (15, 17).

Blood pressure measurements were taken after 30 minutes' rest with the child in a sitting position, the arm placed on a level surface in line with the middle of their sternum/chest, legs unlocked with feet flat on the floor and back straight. Measurements were recorded to the nearest 1mmHg and were taken from the right arm using portable oscillometric blood pressure machines (OMRON-Healthcare-Co HEM-7211-E-Model-M6; Kyoto, Japan) validated every 6 months and appropriate cuff sizes for each child. Three measurements were taken at five-minute intervals with the mean of the last two measurements used in further analyses.

Blood pressure measurements were then compared to percentiles for their age, sex and height of the widely used normative distribution of blood pressure derived from a US population (10).

Children whose systolic or diastolic blood pressure was $\geq 95^{th}$ percentile were measured again several months later, and if still ≥ 95th percentile, followed up for a third and final measurement some months later still. All follow up measurements were completed within 6 -18 months from the first BP assessment. Children with systolic or diastolic blood pressure ≥95th percentile on all three separate occasions were considered to have hypertension (10) and referred to the cohort clinic for urine dipstick and kidney function tests.

Statistical methods

Data management and analysis were conducted in MS Access 2003 and Stata V 15.0 (College Station, TX, US). The crude associations of blood pressure with age, sex, BMI and stunting (as per WHO growth charts) were assessed in simple linear regression models and the regression coefficients, estimating mean effects of each risk factor, presented with 95% confidence intervals, alongside R^2, the proportion of variance in the blood pressure measurements that can be attributed to each risk factor. Next, independent associations were estimated using multiple linear regression with all four potential risk factors included in the model. The prevalence of hypertension based on all three assessments was estimated with the 95% confidence interval derived using bootstrapping. Children with elevated blood pressure who failed to attend reassessment visits were assumed to have comparable blood pressure levels to those who were observed a second and third time.

RESULTS

Of 2882 children aged 6-12 years who were invited to participate in the study from the GPC, a total of 1913 (66%) children presented for study assessments at a centralized location. (Recruitment was affected by the school curriculum. Activities went on while children were at school. When they returned, parents who could, brought them to the hub later in the year. There were no statistically significant demographic differences between attendees and none attendees).

Half of the children who presented for study assessments were male, mean (SD) age 9 (±1.7), the majority (87.7%) were of normal weight, with only 2.9% overweight or obese and almost a tenth underweight. Around one-fifth (22%) of the participants were stunted as per WHO height for age Z- scores (Table 1).

The mean (standard deviation) systolic blood pressure was 113.4 mmHg (± 10.8), and the mean diastolic blood pressure was 69.5 mmHg (± 8.3) at initial assessment. Blood pressure levels increased with age, and girls had on average a higher diastolic blood pressure than boys of the same age (Table 1).

In multivariable analysis, systolic and diastolic blood pressure levels in the study increased on average by 2.1 and 1.2 mmHg respectively ($P<0.001$) for every additional year of age. Girls had 0.9 mmHg [95% CI: (0.0-1.8)] higher mean systolic and 1.5 mmHg [95%CI: (0.8-2.2)] higher mean diastolic blood pressure than boys. Stunting was associated with 4.7 mmHg [95% CI: (3.4 - 5.7)] and 3.2 mmHg [95% CI: (2.3 - 4.0)] lower mean systolic and diastolic blood pressure respectively compared with children of normal height for age. Although a unit increase in BMI was associated with an average increase in systolic and diastolic blood pressure of 0.6 mmHg [95% CI: (0.3 - 1.0)] and 0.3 mmHg [95% CI (0.1 - 0.6)] respectively, this risk factor explained less than 0.7% of the variation in systolic blood pressure measurements and less than 0.3% of the variation in diastolic blood pressure measurements (reflecting the very small numbers of overweight and obese children in this population).

At the initial assessment, 44.2% (846) had systolic or diastolic blood pressure ≥ 95th percentile for their age, sex and height as per the reference distribution and 62.6% (1,197) had systolic and or diastolic blood pressure ≥ 90th percentile for their age, sex and height.

The median (IQR) time between 1st assessment and 2nd assessment was 9.9 (8.0 – 11.2) months and the median (IQR) time between 2nd and 3rd assessment was 1.1 (0.8 - 1.3) months. Of the 846 (44.2%) children who were identified with high blood pressure on the initial assessment, 87 (10%) did not return for reassessment. Of those who returned, 302 (39.8%) had elevated blood pressure again and were invited back for a third assessment. Of the 278 (92%) who returned for their third assessment, 124 (44.6%) still had systolic or diastolic blood pressure greater than or equal to the 95th percentile for their age, sex and height (fig 1).

Overall 1802 children completed all required assessments (figure 1). 6.9% of the children assessed had blood pressure levels higher than the 95th percentile for their age, sex, and height on three separate occasions and were considered to have elevated blood pressure.

Assuming blood pressure levels among the 111 children who failed to attend for reassessments are comparable to those who were observed a second and third time, an estimated 7.8% (0.442 x 0.398 x 0.446) of the children had blood pressure levels ≥ 95th percentile for their age, sex, and height on three separate, consecutive occasions and were considered to have hypertension. There was a higher estimated hypertension prevalence among children 9 years or older (10.6% Vs 5.1%), female children (9.0%) and overweight/obese children (9.4%) although the fraction of hypertension in the population attributable to overweight/obese was negligible (<1%).
Using bootstrapping methods to derive 95% confidence intervals, the prevalence of hypertension in this population was estimated at 7.8% [95% CI:(6.6 - 9.1)], 6.8% [95% CI:(5.1 – 8.5)] among males and 9.0% [95% CI:(7.0 - 11.1)] among females.

Children with elevated blood pressure on all three separate occasions who were referred to the cohort clinic for urine dipstick and kidney function tests were all found to have normal results.

Post-hoc comparison of children LTFU and not LTFU

We compared the demographic and anthropometric characteristics of children who had elevated blood pressure at first sitting and did not get lost to follow up (LTFU), to those who did. Females comprised a larger proportion of children among those LTFU (62% female) than among those not LTFU (48% female) ($p=0.009$), there was a higher proportion of children 10years or older among those LTFU than those not (39% Vs 30%, $p=0.061$). Mean (SD) systolic and diastolic blood pressure at baseline were expectedly higher among those LTFU compared to those not LTFU (123.5 (± 9.3) mmHg Vs 112.8 (± 10.6) mmHg and 76.5 (± 8.0) mmHg Vs .69.1 (± 8.1) mmHg).

DISCUSSION

The mean systolic and diastolic blood pressure found in our study is similar to that reported in a previous study conducted among primary school children in semi urban Uganda (9) where mean systolic and diastolic blood pressure were reported at 116.9 mmHg (± 12.4) and 68.0 mmHg (± 8.7) respectively at first sitting. However, these values are higher than what has been reported in other settings (18, 19). The prevalence of consistently elevated blood pressure over time among children in our study was also relatively high at 7.8% (4, 5, 20) and suggests that the idea that all hypertension is associated with increase in western lifestyle risk factors and is only an urban problem may not be accurate.

Other factors in rural SSA could be causing hypertension early on in children's lives. Several studies (8, 9, 11, 12) have attributed higher blood pressure in rural areas to lower socio economic status exposing children to increased stress perception, infections predominant in rural areas, low birth weight, higher prevalence of being overweight in some rural areas and other environmental factors.

However, the higher levels of baseline blood pressure may also be attributed to white coat hypertension, which could arise as a result of the majority of children in the rural setting not having had their blood pressure measurements taken before, the excitement of taking part in the study and being examined by a nurse or clinician. A previous study among young adolescents (average age 10.2 years) involved in a research birth cohort in Entebbe, Uganda (a semi-urban setting); where children's blood pressure is regularly monitored along with other medical assessments, reported a lower average systolic blood pressure of 105.9 mmHg (SD 8.2) and diastolic blood pressure 65.2 mmHg (SD 7.3) (21).

We also assessed the association between demographic, anthropometric characteristics and high blood pressure, and found significant associations with older age, being female, normal height for age (stunted children had lower blood pressure) and higher BMI, similar to studies from other settings. (3, 4, 9, 12, 22, 23). Particularly, children who were 9 years or older were more likely to be found hypertensive, indicative of the effect of the onset of puberty on blood pressure and possibly other cardiovascular disease risk factors (24). Evidence for sex differences in BP although incoclusive has been documented before (5, 9, 21, 25) . Our results showed that girls had a higher DBP than boys. The mechanisms underlying this finding are unclear but may be a result of differences in haemodynamic factors including; 1) decreased aortic elastance or 2) increased vascular resistance or 3) faster heart rate (26) among girls at that age. Previous research has also attributed higher blood pressure among pre-puberscent female adolscents compared to males to hormonal and other changes associated with puberty

(27-29). More studies are needed to further explore the determinants of sex differences in this setting further.

The prevalence of being overweight/ obese in this population was quite low at only about 3%, and the population attributable fraction for elevated blood pressure for being overweight/ obese was <1%. Early childhood obesity may not be a strong cause for the observed high prevalence of hypertension in adults in SSA. Conversely, early under nutrition, which was much more common among the study participants, with 9% of the children underweight and 22% stunted, has been found to be associated with the occurrence of non-communicable disease later on in life; the so-called "DOHAD" hypothesis (Development Origins of Health and Disease) (30).

According to UNICEF, 2013 "A stunted child enters adulthood with a greater propensity for developing obesity and chronic diseases, with the increasing urbanization and shifts in diet and lifestyle, the result could be a burgeoning epidemic of such conditions in many low and middle income countries" (31). This is more severe when accompanied by excessive weight gain later on in life (14). In our study we found that stunted children had lower average systolic and diastolic blood pressure compared with children of normal height for age. Further studies are needed to understand changes in blood pressure over time among children of stunted growth.

At baseline almost half of the children assessed were reported as having blood pressure ≥ 95th percentile for their age, sex and height as per internationally recognised normograms. This is a high proportion, and was difficult to interpret. Similar results (44.2% above the 95th percentile on day 1) from baseline measurements were also reported by the previous study among primary school children in semi-urban Uganda (9). This could be indicative that the internationally recognised normograms may not be suitable for childen in rural SSA, and studies validating these normograms are needed. Even after considering the possibility of white coat hypertension, this proportion is still quite extreme

Although partly a result of regression to the mean, the drop in the percentage of children with elevated blood pressure between the first occasion and the third highlighted the need for the conduct of multiple measurements of blood pressure over several occasions in studies investigating hypertension among children and young adolescents. A meta-analysis conducted in 2017, estimated it to drop by 77.7% (20). Variations between the baseline blood pressure measure measurements and follow up measurements have been presented in supplementary table 1.

A strength of our study was that it was conducted among children in a rural setting in Uganda. Currently there are very few studies reporting elevated blood pressure prevalence assessed over repeated measurements on separate occasions among children in rural Uganda. The repeat measurements are expected to have reduced the elevated blood pressure resulting from white coat hypertension.

However, this study also had some limitations. We used the fourth report on diagnosis, evaluation and treatment of high blood pressure among children and adolescents (2004). The reference population used for the fourth report included children from the US, and did not include African children. African children are expected to greatly differ from children of similar age and sex in the US by several environmental, psychosocial and developmental characteristics. The lack of context specific reference values for children in the African setting is a great challenge that undermines any research using guidelines adopted from elsewhere.

In addition, unlike the updated guidelines (32) the fourth report guidelines included overweight and obese children. This implies that there is a possibility that our study findings under estimate the true prevalence of hypertension in this population and should be interpreted with that considered.

Not all children who were identified as requiring further assessments returned for follow up assessments. This was addressed by assuming similarity between children lost to follow up and those not. However, on comparing the demographic and anthropometric characteristics of children who had elevated blood pressure at first sitting and did not get lost to follow up, to those who did, females comprised a larger proportion among those lost to follow up (LTFU) than among those not LTFU, there was a higher proportion of children 10years or older among those LTFU than those not and those LTFU had higher baseline blood pressure than those not LTFU. Implying that by assuming similarity between those lost to follow up and those not we may have underestimated the prevalence of elevated blood pressure.

Lastly no data were collected in this study regarding other factors known to be associated with blood pressure (other than age, sex, weight, and height) such as: diets, exposure to smoking, exposure to alcohol, physical activity, birth weight, family history etc. However, information regarding some of these factors among 1054 adolescents in the GPC has been published before (14), but only a small proportion of the hypertension prevalence was explained by the lifestyle factors considered.

Conclusion

The high levels of blood pressure seen among adults in rural Uganda may be set early on in life. Higher blood pressure was associated with higher BMI, being female and being 9 years or older. More research is needed to understand the factors associated with consistently elevated childhood blood pressure in SSA even further. The internationally recognised nomograms (for blood pressure among children) widely used may need to be validated in sub-Saharan African settings.

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CONFLICTS OF INTEREST

Authors have no conflict of interest.

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DATA AVAILABILITY

The datasets generated and/or analysed during this study are available from the corresponding author upon reasonable request. DOI: https://doi.org/10.17037/DATA.00002387

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TABLE LEGENDS

Table 1: Mean blood pressure levels among rural Ugandan children (6-12 years) and associations with sex, age, BMI and stunting.

Table 2: Mean profiles of systolic and diastolic blood pressure by age and sex; a comparison of observed and expected average blood pressure (mmHg).

Supplementary Table 1: Variation of systolic blood pressure and diastolic blood pressure over repeated assessments

FIGURE LEGENDS

Fig 1: Flow diagram showing follow up of children for required visits to assess elevated blood pressure

Table 1: Mean blood pressure levels among rural Ugandan children (6-12 years) and associations with sex, age, BMI and stunting.

		N(%)	Mean (SD)	Average (crude) effect on BP (95% CI)	p-value	R^2	Effect from fully adjusted model (95% CI)	p-value
Systolic blood pressure								
Overall		1913	113.4 (10.8)					
Female		954(49.9)	113.7 (11.3)	0.52 (-0.45 to 1.49)	0.292	0.002	0.86 (-0.02 to 1.75)	0.056
Male		959(50.1)	113.2 (10.3)	*Ref*			Ref	
Age (years)	*M(range)*	9 (6.0,11.9)	113.6 (2.2)#	2.18 (1.91 to 2.44)	<0.001	0.099	2.11 (1.84 to 2.39)	<0.001
BMI (kg/m^2)	*M(range)*	15.3(6.4,30.0)	113.4 (3.9)‡	1.48 (1.17 to 1.80)	<0.001	0.007	0.64 (0.33 to 0.95)	<0.001
Stunted height		424(22.2)	110.5 (10.7)	-3.71 (-4.87 to -2.56)	<0.001	0.032	-4.67 (-3.59 to -5.74)	<0.001
Normal height		1489(77.8)	114.3 (10.7)	*ref*				
Diastolic blood pressure								
Overall		1913	69.5 (8.3)					
Female		954(49.9)	70.2 (8.3)	1.31 (0.57 to 2.05)	0.001	0.008	1.49 (0.79 to 2.20)	<0.001
Male		959(50.1)	68.9 (8.2)	*Ref*			Ref	
Age (years)	*M(range)*	9 (6.0,11.9)	69.6 (1.6)#	1.20 (0.99 to 1.41)	<0.001	0.055	1.21 (0.99 to 1.43)	<0.001
BMI (kg/m^2)	*M(range)*	15.3(6.4,30.0)	69.5 (2.4)‡	0.78 (0.54 to 1.02)	<0.001	0.003	0.31 (0.06 to 0.56)	0.015
Stunted height		424(22.2)	67.4 (8.6)	-2.68 (-3.56 to -1.79)	<0.001	0.026	-3.20 (-2.35 to -4.06)	<0.001
Normal height		1489(77.8)	70.1 (8.1)	*ref*			*Ref*	

Notes: SD = standard deviation. CI = confidence interval. #Mean and SD for a 9-year-old predicted by the simple linear regression. ‡ Mean and SD for a child with average BMI in the study (15.3 kg/m^2) as predicted by the simple linear regression.

M(range): Median (Minimum, Maximum)

R^2: Proportion of variance explained.

Mean (SD) BMI for age Z score: - 0.56 (0.90); Mean (SD) SBP z score: 1.52 (0.94); Mean (SD) DBP Z score: 1.00 (0.70)

Table 2: Mean profiles of systolic and diastolic blood pressure by age and sex; a comparison of observed and expected average blood pressure (mmHg).

Among girls

Age (years)	6	7	8	9	10	11	Overall
Mean (SD) height cm	112 (5.7)	117 (6.0)	123 (6.1)	128 (7.1)	132 (6.6)	137 (7.4)	124 (10.6)
Mean (SD) SBP mmHg	106.2 (8.9)	112.2 (11.9)	113.0 (10.8)	115.9 (10.8)	117.2 (9.6)	117.2 (9.6)	113.7 (11.3)
Expected SBP mmHg	93.4	95.1	97.1	98.8	100.2	101.9	97.5
Mean DBP (SD) mmHg	66.0 (7.5)	69.6 (8.5)	70.3 (7.7)	71.1 (8.3)	71.4 (7.6)	73.8 (8.2)	70.2 (8.3)
Expected DBP mmHg	55.9	57.0	58.1	59.1	59.9	61.0	58.4

Among boys

Age (years)	6	7	8	9	10	11	Overall
Mean (SD) height cm	112 (5.8)	119 (6.1)	124 (6.1)	127 (5.8)	131 (5.9)	135 (7.2)	125 (9.9)
Mean SBP (SD) mmHg	107.9 (9.2)	110.7 (10.2)	112.0 (9.1)	114.9 (9.9)	116.2 (9.7)	117.7 (10.2)	113.2 (10.3)
Expected SBP mmHg	93.6	95.2	96.7	97.5	99.1	101.0	97.2
Mean DBP (SD) mmHg	65.6 (8.1)	67.7 (8.5)	68.2 (7.1)	70.1 (7.5)	71.2 (7.9)	71.0 (8.3)	68.9 (8.2)
Expected DBP mmHg	55.2	56.9	58.2	58.8	59.3	59.8	58.0

Supplementary Table 1: Variation of systolic blood pressure and diastolic blood pressure over repeated assessments

Visit number	**Number of children assessed at visits**	**Systolic Blood pressure (mmHg)** Mean (sd)		**Diastolic Blood pressure (mmHg)** Mean(sd)	
		Baseline average among children assessed at visits	**Average at visit**	**Baseline average among children assessed at visits**	**Average at visit**
Visit 1	1913	113.4 (10.8)	113.4 (10.8)	69.5 (8.3)	69.5 (8.3)
Visit 2	735	122.1 (8.2)	110.1 (10.2)	74.3 (7.9)	72.8 (8.9)
Visit 3	278	124.4 (8.8)	111. (10.1)	75.5 (8.0)	74.4 (7.7)

Only children who had a preceding BP measurement above the 95th percentile for their age, sex and height were invited for a follow assessment. There seems to be a drop in Systolic blood pressure at follow up visits, Diastolic blood pressure seems to be less subject to variation.

Fig 1: Flow diagram showing follow up of children for required visits to assess elevated blood pressure

2882 children (6-12 years) included in the census (2016-2017) and invited to participate

1913 children reported at a centralised location 10-14 days later and are assessed at baseline

- 716 (37·4%) had normal blood pressure
- 351 (18·3%) had BP $\geq 90^{th}$ but $< 95^{th}$ percentile
- 846 (44·2%) had BP $\geq 95^{th}$ percentile

87/846 children with BP $\geq 95^{th}$ percentile on the first assessment were not available for follow up.

759 reassessed overall

- 291 (38·3%) had normal blood pressure
- 166 (21·9%) had BP $\geq 90^{th}$ but $< 95^{th}$ percentile
- 302 (39·8%) had BP $\geq 95^{th}$ percentile

24/302 children with BP $\geq 95^{th}$ on two consecutive assessments were not available for further follow up.

278 reassessed overall

- 94 (33·8%) had normal blood pressure
- 60 (21·6%) had BP $\geq 90^{th}$ but $< 95^{th}$ percentile
- 124 (44·6%) had BP $\geq 95^{th}$ percentile

**Children were considered lost to follow up if they missed a follow up assessment yet were identified as having SBP and/or DBP $\geq 95^{th}$ percentile on preceding assessments.*

**Hypertension was strictly defined as blood pressure levels $\geq 95^{th}$ percentile on three occasions.*