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# Prevalence and Determinants of Elevated Blood Pressure among Children in Rural Kayonza District, Rwanda

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## Abstract

Childhood elevated blood pressure (BP) has emerged as a concern for global public health. In Sub-Saharan African countries, where Rwanda is located, there is a scarcity of BP data for both children and adolescents. Elevated blood pressure (EBP) is a neglected issue in children, it can develop in young age and can last into adulthood. This community-based cross-sectional study in rural Kayonza, Rwanda investigated the prevalence and determinants of elevated blood pressure (EBP) in children aged 36 months. Measurements of blood pressure and height were converted to percentiles using World Health Organization standards. Data collection involved face-to-face interviews with a digital questionnaire. OMRON HBP-1320 blood pressure monitor and SECA 213 stadiometer were used. The mean systolic blood pressure was 90.60 mmHg and 58.75 mmHg and standard deviation of 7.60mHg for diastolic blood pressure. Most child's mothers (76%) were farmers, more than half (62.7%) of child mothers attended primary school, and 36.60% were between the ages of 31 and 35. (Mean age: 30.4 years, Stand. Dev.: 4.4, Minimum age: 21 years and Maximum age: 39 years), (53%) of children were males, 38 % were 36 months old (Mean age: 36.9 months, Stand. Dev.: 1.0, Minimum age: 35 months, and Maximum age: 39 months). Elevated BP for children is defined as being prehypertensive and hypertensive; all children with systolic or diastolic blood pressure percentiles of ≥90th to <95th were prehypertensive, while those with systolic or diastolic blood pressure percentiles of ≥95th to 99th and above were hypertensive. The prevalence of elevated BP was 40.4% with 18.6% being prehypertension and 21.8% being hypertension among 3-year-old children in the rural Kayonza district. Of them 72 (97%) children who had elevated blood pressure, their family were using biomass fuel and 71(36.60%) of study children were below the 5th percentile of height which an indicator of short stature, 27(40.91%) among them had elevated blood pressure. Factors like difficulty getting food on daily basis (food insecurity) (AOR=3.75; 95% CI: [1.70-8.27]; p=0.001) and medium monthly family income (AOR= 2.38; 95% CI: [1.07-5.31]; p=0.033) were associated with increased prevalence of elevated BP. No statistically significant was found between elevated blood pressure and prenatal factors. Mobilization and increase community's awareness on the procedure for measuring children's BP during routine health visits from 3 years old should be done to prevent this increasingly common health condition which is ignored and in asymptomatic nature.

**Keywords**: *Elevated Blood Pressure, Prehypertension, Hypertension, Prenatal Factors, Environmental Factors, Behavioural Factors, Kayonza District, Rwanda.*

## 1. Introduction

High blood pressure, also known as hypertension, has become one of the top ten causes of worldwide disease burden, accounting for 211.8 million Disability Adjusted Life Years (DALYs) each year. The rising prevalence of childhood hypertension, in particular, has sparked global concern (Review, 2021). Childhood hypertension has emerged as a global public health issue. In children and adolescent, the prevalence of hypertension ranges from < 5% to as high as > 20% in African countries. Elevated blood pressure can occur at any age and may persist to adulthood (Muhihi et al., 2018).

Numerous studies have found that children's blood pressure levels are rising, and hypertension (HPT) in young population has been associated with both cardiovascular disease and death later in life (Noubiap, 2020). Blood pressure (BP) monitoring from young age to adult and associated factors help to understand more community level determinants of BP and hypertension. Studies done in African, European and US samples revealed changes in BP and investigated contributing factors for both parents and children. Thus, investigating childhood BP and contributing factors are crucial in explaining increase in life expectancy (Khang & Lynch, 2011). Available finding suggests tracking of BP from early age to adulthood that there is not much information concerning the correlative contribution of prenatal, environmental, parental, behavioural and social determinants to childhood BP (Simonetti et al., 2011).

Childhood EBP has emerged as a concern for global public health and it can be developed early in life and may persist to adulthood (Muhihi et al., 2018). The prevalence of HPT is still rising in Sub-Saharan Africa where Rwanda is located, with the most recent data revealing that more than 30% of the population is affected (Abbafati et al., 2020). Research done revealed that in sub-Saharan African countries where Rwanda is located, there is a scarcity of BP data from both children and adolescents.

Whilst the prevalence of EBP among the children of Rwanda remains unknown. In Rwanda, the prevalence of HPT was more than double in the age group between 55 and 64 years old compared to 44 years old and under (38.6 %). In rural area, 70% of people with HPT were undiagnosed, while 71.2 % were semi-urban (Nahimana et al., 2017).

In Kayonza, HPT is the most common of top six non-communicable diseases. The total annual old cases recorded in Kayonza district HMIS data 2022 were 39223, with an average of 3269 old cases per month and a maximum of 3548 old cases per month for both 0-39 years and above 40 years. Little evidence is known on EBP and associated factors among 3-year-old children in Kayonza, a community where adults appear to have a high prevalence of HPT. HPT is neglected issue in children. Indeed, according to HMIS data 2022 also revealed that the old case for hypertension throughout the Kayonza community aged 0-39 was 616 in males and 1601 in females aged 0-39. However, to date there isn't much research done on BP in children and there are limited facts to understand more the magnitude of elevated BP in children. This research is interested in exploring whether any prenatal, environmental, or behavioural factors impact childhood BP

## 2. Research Objectives

### 2.1 General objectives

The aim of this study was to investigate the prevalence and determinants of elevated BP among children of rural Kayonza, Rwanda.

### 2.2 Specific objectives

(i) To determine the prevalence of elevated BP among 3-year-old children of rural Kayonza district.

(ii) To determine behavioural risk factors for elevated BP among 3-year-old children of rural Kayonza district.

(iii) To determine environmental risk factors for elevated BP among 3-year-old children of rural Kayonza district.

(iv) To identify prenatal risk factors for elevated BP among 3-year-old children of rural Kayonza district.

## 3. Empirical literature

### 3.1 Prevalence of EBP in children and adolescents

The prevalence of HPT is still rising in Sub-Saharan Africa, with the most recent data revealing that more than 30% of the population is affected. The prevalence of HPT in children varies by country, ranging from 1-5% (Abbafati et al., 2020). A recent meta-analysis data revealed the global prevalence rate of HPT which was 4.0 % (95 %CI: 3.3 % -4.8 %) and prehypertension was 9.7 % where 95 % CI, ranging 7.3 % to 12.4 %. A meta-analysis of data for 54000 aged 2 to 19 years children of Africa found a prevalence of 5.5 percent (95% CI, ranging (4.2- 6.9) for EBP and 12.7 % with 95 % CI, ranging 2.1 to 30.4 for prehypertension. This study also discovered a strong relationship between high BP and being obese. It was 6 times greater in obese (30.8%) than in normal weight children (5.5 %) and $p < 0.0001$) (Abbafati et al., 2020).

According to various studies, childhood hypertension progresses to HPT later in life. According to the findings of a community-based study, 5.9 % of young people aged 10-17 years old with persistently elevated blood pressure had HPT after 2 years (Noubiap, 2020). EBP in young children and teenagers is a pressing health issue in the world that is not frequently considered by Physician. Prehypertension in the USA affects 3.4 % of aged 3-18-year-old children, and HPT affects 3.6%. Same study also revealed the prevalence of EBP in obese teenagers which was more than 30% in boys and 23-30% in girl (Riley et al., 2018).

The emergence of EBP early in life and its persistence cause HPT in adolescents (Placide Kambola et al., 2021). Data collected in children in North America over a long period suggested a prevalence of HBP ranged 2% to 5%. There is a scarcity of data on the prevalence of HBP in African children, the recent data review on HBP in south Africa showed a prevalence of high BP between 7.5% to 22.3%. In children, a higher proportion of high BP cases were found to be secondary high BP than in adults; in developed countries, primary high BP is more common than secondary high BP in children, with obesity as a relative risk factor. However, the potential relative risk factor of primary and secondary high BP is still unknown in developing countries (Kidy et al., 2014).

In the cross-sectional study done in the Republic of Cyprus in children aged 10 to 12 years revealed that the median SBP/DBP for both boys and girls was 110 (100–120) mmHg /65 (60–70) mmHg. Finding revealed no distinction between girls and boys. In fact, SBP and DBP levels were present in 13.3% of boys and 8.8 % of girls which were higher than 120/80 mmHg. When this result is compared to the American reference cut-offs of the 90th percentile, the result is 13.9 % for boys and 15.4 % for girls (Lazarou et al., 2009).

Noubiap (2020) in a cross-sectional study done in the Sub-Saharan African region, specifically in Mwanza, Tanzania found that elevated BP was in 8.5 % of the children while prehypertensive children was 9.6 %. The adjusted odds ratio (aOR) at 10 years age was 1.9 with 95 % CI, ranging 1.2 to 2.9, then for female sex aOR was 1.5 with 95 % CI, ranging 1.1 to 2.3, aOR for overweight was 1.9, 95 % CI, ranging 1.1 to 3.3, aOR for obesity was 3.5, 95 % CI ranging 1.6 to 7.7, aOR eating fried food was 2.2, CI of 95 %, ranging 1.1 to 4.4, aOR for drinking sugary soft drinks was 2.0, CI of 95 %, ranging 1.2 to 3.5 (Noubiap, 2020).

Kidy et al. (2014) in their follow-up study in 7 to18 years old school children in Uganda found that the mean (SD) SBP at baseline, which was the same as this study, was 116.9mmHg, while the mean DBP was 68.0mmHg. This study's findings also revealed that 92 (17.1 %, 95 % CI: 13.9 % to 20.2 %) of the participants had HPT, and the adjusted OR for BM was 1.70, 95% CI ranging 1.25 to 2.31, $p = 0.001$, which was associated with rise in HPB. Sustained high BP was found to be 3.8 % prevalent in Uganda (95 % CI: 2.4 % -5.9 %) (Kidy et al., 2014).

In Rwanda, a study done in Bugesera on a population aged 15-64 years revealed a prevalence of 16.8 % for HBP. HBP risk factors identified include age, obesity, dietary intake, and physical inactivity. In Rwanda, the prevalence of HPT was 15.4 % with 95 % confidence interval of (14.6 % to 16.3 %), with males having 16.5 % with 95 % confidence interval of (15.1 % to 18.0 %) and females having 14.4 % with 95 % confidence interval of (13.4 % to 15.5 %). HPT prevalence was more than double in the 55-64 age group, compared to 38.6 % in the 44-year-old group and below. In rural area, 70% of people with HPT were undiagnosed, while 71.2 % were semi-urban (Nahimana et al., 2017). A cross-sectional study done also in Rwandan tertiary institution discovered that 36% of staff were hypertensive. The level of awareness was low among HPT participants. Pande & NIYONZIMA (2010) in their review of medical record in Ruhengeri DH, HPT account for 2.5%, 47.4% among them were severe HPT (Pande & NIYONZIMA, 2010).

According to health facility data, the proportion of people consulted for HBP increased in Rwanda from 1.9 % in 2009 to 6.4 % in 2014. There is a discrepancy between the prevalence of HTP in the community and data from health facilities, which is attributed to HPT which occur in asymptomatic nature and the fact that people are unaware of their health status. Community-based data, on the other hand, provides a more accurate picture of a real disease burden (Nahimana et al., 2017).

### 3.2 Behavioural risk factors of elevated BP

In their cross-sectional study conducted in India, Rajkumar & Romate,2020 discovered that smoking behaviour (Odd Ratio = 0.29 with 090–0.961 CI) was significantly associated with the odds of HPT. Even if it is associated, the value of odds ratio was lesser, the results showed smokers had lower risk of hypertension (Rajkumar & Romate, 2020).

In the cross-sectional study done in the Republic of Cyprus in children aged 10 to 12 years, this study looked at the correlation of confounding variables such as age, gender, diet quality, physical activity, watching television, and eating while watching, and found that most of the variables had a non-significant effect (Lazarou et al., 2009). Children from urban areas had lower BP levels than those from rural areas. The 120/80mmHg and 90th percentile values were significantly related to 90th percentile cut-offs resulted in 13.9 % for boys and 15.4 % for girls (Lazarou et al., 2009). Liang et al. (2020) in their cross-sectional study done in 6-12-year children in urban and rural China, discovered that children who had HPT linked with its determinant was 16.25 % for obese children, 16.31 % for maternal gestational HPT and 29.4 % for low family income and a higher prevalence and low physical activity were all statistically significant (p= 0.05) (Liang et al., 2020). The analysis of age, obesity, income, birth weight and physical activity suggested that HPT was more prevalent in rural areas. In fact, malnutrition increases the risk of developing HPT (Liang et al., 2020).

### 3.3 Environmental risk factors of elevated BP

The increase of 20mm Hg in SBP or 10mmHg in DBP is correlated with an increase in cardiovascular mortality (Choi et al., 2019). BP is a variable; acute or exposure to air pollutants over the course of a long time affects children's BP. Depending on environmental exposure period, vascular changes begin early in life in utero which affect BP homeostasis (Farzan et al., 2018). Parental smoking had an independent effect on SBP (P=0.001), and exposed children to smoking during pregnancy had significantly elevated SBP values than children who is not exposed, as did children of hypertensive mothers during pregnancy. Smoking was prevalent in 42.6 % of parents with a lower level of education, and it was associated with higher SBP values (Simonetti et al., 2011). The descriptive analysis revealed that participants with a history of smoking, low physical activity, and alcohol consumption had an increased prevalence of HPT (Nahimana et al., 2017).

The acute ambient air pollution exposure on BP, can rise BP within few hours of being exposed to elevated nitrogen dioxide (NO2). HAP is linked with increased CV mortality and morbidity. Air pollutants cause systemic inflammation, endothelial dysfunction, at herogenesis and increase in BP. This led to elevated BP. Conflicting results were shown by the study linking arterial BP and air pollution (Choi et al., 2019). Epidemiological studies have suggested that higher daily exposure to PM levels causes an acute increase in systemic BP. Per 10 g/m3 increase in PM, the effect occur when systolic and diastolic BP rises by 1 to 4 mmHg. CO appears to contribute to vasorelaxation in the celebro-vascular circulation, according to experimental studies and RCT intervention aiming at reducing indoor air pollution showed an impact on better blood pressure (Choi et al., 2019).

### 3.4 Prenatal factors and children's BP

Complications during pregnancy can affect the blood pressure of young adults. Patients with HPT should make active lifestyle changes such as quitting smoking, weight control, lowering salt intake, and rising physical activity. Pre-hypertension during pregnancy has been linked to

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hypertension and some other diseases in adult (Jun & Yali, 2020). Simonetti et al. (2011) discovered in their follow up study of 4-7.5-year-old children in Germany that SBP and DBP of children with prematurity, low birth weight, and hypertensive parents were elevated in children of smoker parents.

Children with prenatal risk factors and low birth weight had significantly higher SBP values than children born with 2500g and above (Simonetti et al., 2011). Whereas after adjusting age, gender, and height, it was discovered birth weight was found to be a protective factor against childhood hypertension (p= 0.05) for all (Liang et al., 2020). Kaczmarek et al. (2015) in their cross-sectional study discovered that paternal occupation and income sufficiency were linked to systolic prehypertension. The adjusted likelihood of developing HPT decreases as maternal education increases, as does the likelihood of developing prehypertension as maternal education, paternal employment status, and income adequacy increase. The findings also confirmed that parental HPT was a major predictor of both prehypertension and HPT in adolescents, that maternal occupational status was related to education, and that parental occupation and family size had no effect on BP (Kaczmarek et al., 2015). Elevated BP in children can result to HPT in adults. There are theories that explain HBP in teenagers for children born prematurely or underweight. These effects were from poor maternal nutrition during pregnancy.

BP is affected by many other factors; the strong predictor factor is body weight. Family history and many of the diseases may affect genetic and arterial BP flow during childhood growth. Genetic factors influence BP trajectories in children.

The determinants of SBP include height, genetic factors, environmental factors, and obesity (Oh & Hong, 2019). In fact, evidence from a study conducted in Mwanza, Tanzania suggests that underweight at birth, maternal condition during pregnancy such as being hypertensive, being obese and diabetes are linked with a high risk of having abnormal BP in children (Noubiap, 2020). However, the prevalence and determinants of elevated BP in Rwandan children remains unknown.

### 3.5 Research Gap

Studies were or have been conducted to determine the prevalence of high BP in children and adolescents. Similar research was carried out in China (Liang et al., 2020), Germany (Simonetti et al., 2011), North America (Kidy et al., 2014), Tanzania (Noubiap, 2020), Uganda (Kidy et al., 2014), and the Republic of Cyprus (Lazarou et al., 2009). All these studies were cross-sectional and community-based, with a common focus on EBP in children and adolescents aged 4 and above. Except for a meta-analysis done in sub–Saharan Africa (Noubiap, 2020) which discovered EBP in children aged 2 to 19, and one study conducted in Rwanda (Nahimana et al., 2017) with targeted population aged 15 to 64 years old.

Given that elevated BP is a neglected issue in children and people are unaware of their health status regarding hypertension because HPT is asymptomatic, elevated blood pressure has not been considered by frontline health workers, including physicians. However, no community-based study done on EBP in children under the age of five has been conducted in Eastern Africa or Rwanda. This study aims to identify environmental, behavioural, and prenatal risk factors as determinants of EBP in 3-years old children.

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## 4. Materials and Methods

### 4.1 Research design

This research is a cross-sectional quantitative descriptive study.

### 4.2 Study area

This research was conducted in three sectors of the rural Kayonza District, which is in Rwanda's Eastern province. These sectors were Kabarondo, Kabare, and Murama. Each sector has a total population of 30588, 34460 and 19945 respectively (Kilombero District, 2013).

### 4.3 Target population

The target population was Household air pollution intervention network trial (HAPIN trial) children. The HAPIN trial is a multi-country RCT that is looking at the impact of using cleaner fuel as an intervention for pregnant women who cook with biofuel. The trial aimed to assess the health consequences of stunting at one year, birth weight, the prevalence of severe pneumonia among children under one year old, and blood pressure among older women living with pregnant women. HAPIN trial enrolled 3195 pregnant women from Guatemala, India, Peru, and Rwanda. Households assigned to the intervention arm receive an LPG stove and an 18-month free supply of gas. During the follow-up period, control participants were expected to cook primarily with biomass. A cohort study is currently underway to continue following HAPIN participants and assess the effects of the intervention until the child's fifth birthday. The HAPIN trial enrolled 800 Rwandan children. Some participants were lost for follow-up, moved out of the study area, or died during the follow-up period. Only 732 children and mothers have completed all follow-up visits and are currently being enrolled in the HAPIN 2 cohort study. Among enrolled children, 376 children were 3 years old up to July 2022, and a sample of these children was drawn for this study.

### 4.4 Sample size

This study's sample size was determined using Yamane's formula ($\frac{\mathrm{N}}{1+\mathrm{N(e)}^2}$) (Yamane, 1967). The sample size calculation assumes an estimate of a proportion for elevated BP being 0.5. The total number of 376 children is drawn from HAPIN scheduled list for 36-month visits.

The margin of error (e) is the precision for estimating a proportion of 0.5, the desired precision is plus or minus 5% and the sample size calculation considers a population of 376 children. Therefore, the sample size (n), is equal n= $(\frac{N}{1+N(e)^2})$= $(\frac{376}{1+376(0.05)^2})$=194

The total sample of 194 children aged 3were enrolled in this study.

### 4.5 Sampling technique

HAPIN trial were a randomized control trial and at baseline the participant were randomly selected. HAPIN 2 cohort study is a continued follow up of HAPIN children. HAPIN 2 cohort study has 4 annual visits at 24, 36, 48, and 60 months. The current study is a sub study of HAPIN 2 follow up study. A consecutive enrolment of children visited by HAPIN staff at 36 months were enrolled in this study until when the calculated sample size is reached. The HAPIN 2 follow up study has visits range, 36-month visit occur when a child is in between 35-39 months, this range was respected.

### 4.6 Data collection instrument

Data collection was done using a questionnaire. A questionnaire is the best method of collecting accurate data from a big number of respondents. This method of data collection does not put much pressure on participants, and it ensures anonymity. Questionnaire made of questions about food and drinks which can have acute effect on BP, prenatal, behavioural, and environmental factors as well as height was administered. The questionnaire was administered through a face-to-face interview technique.

Height was measured using SECA 213 stadiometer. Average of two taken measurement was used. Using WHO growth standards (Height-for-Age BOYS Height-for-Age BOYS, n.d.; Height-for-Age GIRLS Height-for-Age GIRLS, n.d.), height were plotted into height percentile and sitting BP was measured three times by auscultatory BP, OMRON HBP-1320 BP monitor which is recommended by (Flynn *et al*., 2017) . An appropriate cuff size adapted to arm circumference in accordance with standardized procedural guidelines was used (Simonetti et al., 2011). The next two measurements were taken at 2-minute intervals. The child's BP were measured three times, and the average of the last two measurements was used. According to "(Blood Pressure Levels for Boys by Age and Height Percentile. Nhlbi.nih.gov. 2019.)" before establishing BP levels in children, the results of SBP and DBP must be plotted into BP and height percentiles. (Roccella, 1996). Using American reference table, the result of SBP and DBP were converted into BP percentiles (Fujii, 2013; Roccella, 1996). The average for both SBP and DPB found to be ≥90 percentiles was defined as EBP.

### 4.7 Data analysis

The completed data collection checklist in ODK was double-checked for completeness and cleaned and then exported to Stata for further statistical analysis. To investigate the data in relation to relevant variables, descriptive statistics namely chi-square, Pearson correlation, binary logistic regression and multiple logistic regression were generated and presented in both tables and figures for relevant variables. To examine the association between outcome and independent variables, binary logistic regression was used. The statistical significance level was set at P-value <0.05 and to determine the independent predictors of EBP, multiple logistic regression was used for all variables with p-values below 0.05.

### 4.8 Ethical consideration

Mount Kenya University Rwanda's School of Postgraduate Studies approved the research proposal, and ethical clearance was obtained from Mount Kenya University Rwanda's Institutional Research and Ethics committee. Following MKU's ethical approval, the study was approved by Emory University. The approval letter was presented to the HAPIN principal investigator. Prior to data collection, a consent form was conducted, after consenting, participant have chosen voluntary to participate or not, it they choose to participate, a consent form was signed by both participants and HAPIN staff. The study staff kept one signed copy, while the participant keep the other. All

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the information were kept confidential, and no participants' names, addresses, or other identifying information was collected.

## 5. Results

According to Table 1, most child's mothers 148(76%) were farmers. This is explained by the fact that the Kabare, Kabarondo, and Murama sectors are in rural areas where agriculture is the primary activity. More than half of the children 103(53%) were male, 74(38%) were 36 months old (Mean age: 36.9 months, Stand. Dev.: 1.0, Minimum age: 35 months, and Maximum age: 39 months), and 60(36.60%) were below 5th percentile of height. More than half 121(62%) of child mothers attended primary school, and 71(36.60%) were between the ages of 31 and 35. (Mean age: 30.4 years, Stand. Dev.: 4.4, Minimum age: 21 years and Maximum age: 39 years).

**Table 1. Sociodemographic Characteristics of mothers and their children of rural Kayonza district**

| Variables | | Frequency (n=194) | Percent (%) |
|---|---|---|---|
| **Child's age** | 35 months | 3 | 1.55 |
| | 36 months | 74 | 38.14 |
| | 37 months | 68 | 35.05 |
| | 38 months | 30 | 15.46 |
| | 39 months | 19 | 9.79 |
| **Child's gender** | Boys | 103 | 53.09 |
| | Girls | 91 | 46.91 |
| **Child's height percentile** | Below 5th | 71 | 36.60 |
| | 5th -10th | 60 | 30.93 |
| | 10th -25th | 23 | 11.86 |
| | 25th-50th | 29 | 14.95 |
| | 50th -75th | 9 | 4.64 |
| | 75th -90th | 1 | 0.52 |
| | 90th -95th | 1 | 0.52 |
| **Mother's age** | 20-25 years | 38 | 19.59 |
| | 26-30 years | 58 | 29.90 |
| | 31-35years | 71 | 36.60 |
| | 36 years and above | 27 | 13.92 |
| **Mother's Occupation** | Private and Public employee | 46 | 21.71 |
| | Farmer | 148 | 76.29 |
| **Father's Occupation** | Private and Public employee | 76 | 39.18 |
| | Farmer | 110 | 56.70 |
| | Don’t know | 8 | 4.12 |
| **Mother's education** | No formal education | 14 | 7.22 |
| | Primary school | 121 | 62.37 |
| | Secondary school | 54 | 27.84 |

| | | | |
|---|---|---|---|
| | University | 5 | 2.58 |
| **Father's education** | No formal education | 20 | 10.31 |
| | Primary school | 115 | 59.28 |
| | Secondary school | 50 | 25.77 |
| | University | 9 | 4.64 |

**Source: Primary data (2022)**

The prevalence of elevated BP was obtained after converting height into height percentiles using WHO Height for Age and then compared to the American 90$^{th}$ percentile reference cut-offs BP table by age. Elevated BP was defined as average SBP or DBP ≥ 90th percentile for age, gender, and height of the child. Elevated BP is made up of prehypertension and hypertension; all children with SBP or DBP percentiles of ≥90th to <95th were prehypertensive, while those with SBP or DBP percentiles of ≥95th to 99th and above were hypertensive as it is shown on figure 1 and 2.

**Figure 1:Prevalence of elevated BP among 3-year-old children of rural Kayonza district.**

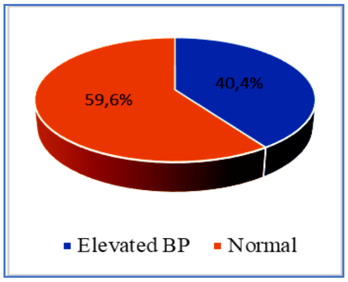
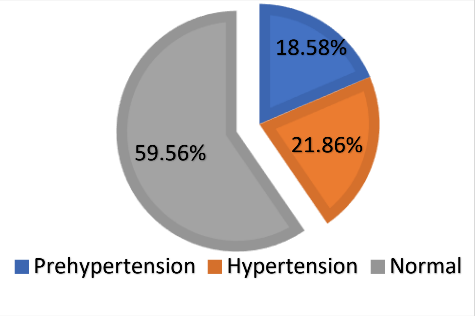



Figure 4.1 shows that the prevalence of elevated BP was 74/183 (40.4%) in a total of 194 children enrolled in the study. This is because 11(5.7%) of the BP measurements were missed.

**Source: Primary data (2022)**

**Figure 2: Prehypertension and hypertension among 3-year-old children of rural Kayonza district.**




According to Figure2, among the 40.4% of children with elevated BP, 18.58% had prehypertension and 21.86% had hypertension.

**Source: Primary data (2022)**

**5.1 Factors associated with elevated BP among aged 3-year-old children.**

A bivariate analysis revealed no association between elevated BP and sociodemographic characteristics, as shown in Table2. As the p value was greater than 0.05, no association was found between elevated BP and gender, age, level of education, child's height percentile, or occupation.

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**Table 2. Sociodemographic characteristics associated with elevated BP among aged 3-year-old children.**

| Variables | | Elevated BP | | Chi-square | P-value |
|---|---|---|---|---|---|
| | | Yes n (%) | No n (%) | | |
| **Child's age** | 35 months | 1(33.33) | 2(66.67) | 6.6377 | 0.156 |
| | 36 months | 36(51.43) | 34(48.57) | | |
| | 37 months | 24(37.50) | 40(62.50) | | |
| | 38 months | 8(28.57) | 20(71.43) | | |
| | 39 months | 5(27.78) | 13(72.22) | | |
| **Child's gender** | Boys | 40(40.40) | 59(59.60) | 0.0001 | 0.992 |
| | Girls | 34(40.48) | 50(59.52) | | |
| **Child's height percentile** | Below 5th | 27(40.91) | 39(59.09) | 1.3489 | 0.930 |
| | 5th -10th] | 21(36.84) | 36(63.16) | | |
| | ]10th -25th] | 10(45.45) | 12(54.55) | | |
| | ]25th-50th] | 12(42.86) | 16(57.14) | | |
| | ]50th -75th] | 4(44.44) | 5(55.56) | | |
| | ]75th -90th] | 0(0.00) | 1(100.00) | | |
| **Mother's age** | 20-25 years | 17(47.22) | 19(52.78) | 1.9321 | 0.587 |
| | 26-30 years | 24(43.64) | 31(56.36) | | |
| | 31-35years | 25(37.31) | 42(62.69) | | |
| | 36 years and above | 8(32.00) | 17(68.00) | | |
| **Mother's Occupation** | Private and Public employee | 16(39.02) | 25(60.98) | 0.0438 | 0.834 |
| | Farmer | 58(40.85) | 84(59.15) | | |
| **Father's Occupation** | Private and Public employee | 26(36.62) | 45(63.38) | 1.3346 | 0.513 |
| | Farmer | 44(41.90) | 61(58.10) | | |
| | Don't know | 4(66.67) | 2(33.33) | | |
| **Mother's education** | No formal education | 4(40.00) | 6(60.00) | 2.1203 | 0.548 |
| | Primary school | 50(42.74) | 67(57.26) | | |
| | Secondary school | 17(33.33) | 34(66.67) | | |
| | University | 3(60.00) | 2(40.00) | | |
| **Father's education** | No formal education | 7(36.84) | 12(63.16) | 0.1765 | 0.981 |
| | Primary school | 44(40.37) | 65(59.63) | | |
| | Secondary school | 19(41.30) | 27(58.70) | | |
| | University | 4(44.44) | 5(55.56) | | |

**Source: Primary data (2022)**

Results in Table 3 showed that there was an association between elevated BP and the diet with fruits and vegetables (p= 0.015) and food security for the family (p<0.017). The alcohol

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consumption, physical activity, and parental smoking have not been found to be associated with elevated BP in the bivariate analysis (p value > 0.05).

**Table 3. Behavioural risk factors associated with elevated BP among 3-year-old children of rural Kayonza district.**

| Variables | | Elevated BP Yes n (%) | Elevated BP No n (%) | Chi-square | P-value |
|---|---|---|---|---|---|
| **Children ate Diet with Fruits and Vegetables** | None | 7(87.50) | 1(12.50) | 8.4138 | **0.015** |
| | 1-6 times per week | 54(40.00) | 81(60.00) | | |
| | Daily | 13(32.50) | 27(67.50) | | |
| **Alcohol consumption for child's mother** | Never | 66(43.14) | 87(56.86) | 2.8250 | 0.093 |
| | During pregnancy and after birth | 8(26.67) | 22(73.33) | | |
| **Food security for the family** | Easy | 23(58.97) | 16(41.03) | 8.1558 | **0.017** |
| | Difficult | 43(33.86) | 84(66.14) | | |
| | Too difficult | 8(47.06) | 9(52.94) | | |
| **Daily physical activity of the child** | Below 30min | 39(42.39) | 53(57.61) | 0.2933 | 0.588 |
| | Above 30min | 35(38.46) | 56(61.54) | | |
| **Parental smoking** | Yes | 2(50.50) | 2(50.50) | 0.1553 | 0.694 |
| | No | 72(40.22) | 107(59.78) | | |

**Source: Primary data (2022)**

A bivariate analysis revealed no association between elevated BP and prenatal factors however, according to the findings presented in Table 4, the researcher found that socioeconomic status ($p<0.021$) was statistically significant associated with elevated blood pressure in 3-year-old children from the rural Kayonza district. There was no association found between the number of family members, the education of the mother and father, living with both parents, noise, exposure to HAP current fuel, exposure to HAP during pregnancy and elevated blood pressure ($p>0.05$).

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**Table 4. Environmental risk factors for elevated BP among 3-year-old children of rural Kayonza district.**

| Variables | | Elevated BP | | Chi-square | P-value |
|---|---|---|---|---|---|
| | | Yes n (%) | No n (%) | | |
| **Monthly family income** | Low (< 60000 Rwf) | 28(51.85) | 26(48.15) | 7.7003 | **0.021** |
| | Medium (60000-100000Rwf) | 19(27.94) | 49(72.06) | | |
| | High (above 100000 Rwf) | 27(44.26) | 34(55.74) | | |
| **Number of family members** | 1-2 persons | 19(52.78) | 17(47.22) | 2.8337 | 0.092 |
| | 3persons and above | 55(37.41) | 92(62.59) | | |
| **Mother's education** | No formal education | 4(40.00) | 6(60.00) | 2.1203 | 0.548 |
| | Primary school | 50(42.74) | 67(57.26) | | |
| | Secondary school | 17(33.33) | 34(66.67) | | |
| | University | 3(60.00) | 2(40.00) | | |
| **Father's education** | No formal education | 7(36.84) | 12(63.16) | 0.1765 | 0.981 |
| | Primary school | 44(40.37) | 65(59.63) | | |
| | Secondary school | 19(41.30) | 27(58.70) | | |
| | University | 4(44.44) | 5(55.56) | | |
| **Living together with both parents** | Yes | 65(40.12) | 97(59.88) | 0.0577 | 0.810 |
| | No | 9(42.86) | 12(57.14) | | |
| **Noise** | Exposed | 16(43.24) | 21(56.76) | 0.1516 | 0.697 |
| | Not exposed | 58(39.73) | 88(60.27) | | |
| **Exposure to HAP_ current fuel** | Biomass fuel | 72(40.22) | 109(59.78) | 0.1553 | 0.694 |
| | Liquefied Petroleum Gas | 2(50.00) | 2(50.00) | | |
| **Exposure to HAP_ fuel during pregnancy** | Biomass fuel | 44(41.51) | 62(58.49) | 0.1203 | 0.729 |
| | Liquefied Petroleum Gas | 30(38.96) | 47(61.04) | | |

**Source: Primary data (2022)**

## 5.2 Discussion

The prevalence of elevated BP was found to be 40.4% as shown in Figure 1. This study's results was found to be high compared to the results of some other similar studies done in different areas, where their results revealed that elevated BP is prevalent at 15.2 % in Dar-es-Salam, Tanzania (Muhihi et al., 2018), 30.6% in Lubumbashi RDC (Placide Kambola et al., 2021). The disparity between the prevalence of elevated blood pressure may be related to the fact that Rwandan children's growth differs from the children used when converting WHO height for age into height percentiles. In fact children for this study might have some other commodities like renal disease and malnutrition, early scientist revealed that vascular changes begin early in life in utero which affect BP homeostasis (Farzan et al., 2018).

The results of this study also found 18.58% of children had prehypertension and 21.86% had hypertension as shown in Figure 2. This is comparable to the results of a study on children aged 7-18 conducted in Uganda which found that 17.1% children had hypertension (Kidy et al., 2014). It is high compared to the study conducted China which found 13.75% of children aged 6-12 had hypertension(Liang et al., 2020).

In Sao Paulo, in the study conducted in malnourished children aged 2-7 years, the prevalence of elevated BP was 42% (Sesso et al., 2004), which is somehow similar to the 40.4% found in this study even if the characteristics of respondents were different.

Researchers thought that the higher prevalence of elevated BP found in this study was because 36.60% of study children were below the 5th percentile of height as it is indicated by Table 1. Height is an indicator of short stature (Fiedorowicz et al., 2000) and results on Table 2 showed that 40.91% of them had elevated BP. This explains the higher prevalence of elevated BP because height is a precise measure for BMI and maturation which account for primary factors of the natural rise of childhood BP, it is the primary metric reference than age. This is due to height accounts for a greater proportion of BP variability in children than age.

Other study's finding showed that children from urban areas had lower BP levels than those from rural areas (Liang et al., 2020). In conjunction with this study's finding revealed that after the end of HAPIN intervention 72 (97%) children who had elevated BP, their family were using biomass fuel and other recent study showed that air pollutants cause systemic inflammation, endothelial dysfunction, atherogenesis and increase in BP which led to elevated BP (Choi et al., 2019) therefore HAP exposure response to children's BP might be another fact for higher prevalence, and it was shown in epidemiological studies suggested that higher daily exposure to PM levels causes an acute increase in systemic BP. Per 10 g/m3 increase in PM, the effect occur when systolic and diastolic BP rises by 1 to 4 mmHg. CO appears to contribute to vasorelaxation in the celebro-vascular circulation, according to experimental studies and RCT intervention aiming at reducing indoor air pollution showed an impact on better BP (Choi et al., 2019).

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**Table 5. Changes in Adjusted Odds Ratios (95% CI) of Elevated BP After adjustment for environmental and behaviour factors, results from this study.**

| Characteristics | Items | Crude OR (95%CI) | P-value | Adjusted OR (95%CI) | P-value |
|---|---|---|---|---|---|
| **Children ate Diet with Fruits and Vegetables** | None | .068(.007-.61) | **0.017** | .038(.003-.37) | **0.005** |
| | 1-6 times per week | .72(.34-1.52) | 0.392 | .054(.24-1.22) | 0.144 |
| | Daily | Ref. | | Ref. | |
| **Monthly family income** | Low (<60,000Rwf) | .73(.35-1.53) | 0.417 | .70(.31-1.57) | 0.393 |
| | Medium (60,000-100,000 Rwf) | 2.04(.98-4.25) | 0.055 | 2.38(1.07-5.31) | **0.033** |
| | High (above 100,000Rwf) | Ref. | | Ref. | |
| **Food security for the family** | Easy | Ref. | | Ref. | |
| | Difficult | 2.80(1.34-5.86) | 0.006 | 3.75(1.70-8.27) | **<0.001** |
| | Too difficult | 1.61(.51-5.08) | 0.411 | 2.38(.68-8.35) | 0.174 |

**Source: Primary data (2022)**

Results from multivariate analysis on Table 5 showed that children living in a household with medium monthly family income were found to be significantly associated with an increased risk of developing elevated BP (AOR= 2.38; 95% CI: [1.07-5.31]; p=0.033) compared to children living in a household with high monthly family income. This results is supported by a study conducted in China in children aged 6-12- (Liang et al., 2020), Kaczmarek et al.(2015) in their cross-sectional study discovered that paternal income sufficiency were linked to systolic prehypertension. The adjusted likelihood of developing HPT decreases as does the likelihood of developing prehypertension as income adequacy increase (Kaczmarek et al., 2015).The difference was analytical methods used, sample size and children's age. Researcher thought that family income is linked with nutrition of the family, where malnutrition led to elevated BP.

According to this study's results on Table 5, children living in a house where getting food on daily basis was difficult (food insecurity) were 3.75 times (AOR= 3.75; 95% CI: [3.75]; p=0.001) more likely to develop elevated BP in young age than children living in a house with food security. There is no study done on children under five to associate food insecurity and children's BP, however this finding was inconsistent with what was discovered in a USA study (Berkowitz et al., 2013), which found that food insecurity was not associated with BP control in diabetics adults. According to (Liang et al., 2020) malnutrition increases the risk of developing elevated BP because previous research suggested that severe malnutrition may cause vascular endothelial damage, increasing the risk of high BP (Astria Hannah et al., 2017).

Food insecurity led to malnutrition. Referring to Table 5 children who never ate diet containing fruits and vegetables were .038 times more likely to develop elevated BP than children from a family which ate diet containing fruits and vegetables daily ([AOR=.038; 95% CI: .003-.37];

p=0.005). This cannot be used as predictor of elevated BP because the effect regress ([COR = .068] < [AOR=.038]. However study done in children aged 10 to 12 years in the Republic of Cyprus found that diet quality had a non-significant effect (Lazarou et al., 2009) on elevated BP.

This study's results did not find an associated factors with prenatal factors, and this is because binary analysis did not find a p-value below 0.05. It is inconsistent compared to other studies done anywhere else as it was found in Germany (Simonetti et al., 2011). The reason might be due to difference in study setting and sample size, family history, monthly family income and maternal conditions during pregnancy differ and in this study on Table 4.5 underweight was at 1(1.4%) for children who had elevated BP.

The study identified two potential limitations: (1) BP is a neglected issue in children, and there hasn't been much research on childhood BP. The findings of this study were compared to a few similar studies conducted in children over the age of four. A similar study on children's blood pressure was not conducted in Rwanda. (2) 5.7% of the children as shown on Figure 1 did not have their blood pressure measured because they were unstable, terrified, or cried excessively

## 6. Conclusions

This study found a higher prevalence of elevated BP than other similar studies which was found to be 40.4%. Of them 18.58% of children had prehypertension and 21.86% had hypertension. Predictors like difficulty to get food on daily basis (food insecurity) (AOR=4.08; 95% CI: [1.85-9.01]; p=0.000) and medium monthly family income (AOR=3.11; 95% CI: [1.40-6.90]; p=0.005) were found to be statistically significantly associated with elevated BP. No statistically significant was found between elevated BP and prenatal factors.

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## References

[1] Astria Hannah, R., Sekarwana, N., & Effendi, S. I. (2017). Prevalence of Moderate Malnutrition in School-age Children and Its Association with Hypertension and Microalbuminuria. American Journal of Clinical Medicine Research, 5(1), 6–9. https://doi.org/10.12691/ajcmr-5-1-2

[2] Berkowitz, S. A., Baggett, T. P., Wexler, D. J., Huskey, K. W., & Wee, C. C. (2013). Food insecurity and metabolic control among U.S. Adults with diabetes. Diabetes Care, 36(10), 3093–3099. https://doi.org/10.2337/dc13-0570

[3] Blood Pressure Levels for Boys by Age and Height Percentile. Nhlbi.nih.gov. 2019. Available from: https: www.nhlbi.nih.gov/files/docs/guidelines/child_tbl.pdf. (2001).

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**Email: info@stratfordjournals.org ISSN: 2706-6606**

Blood Pressure Levels for Boys by Age and Height Percentile. Journal of Clinical Gastroenterology., 33(4), 289–294.

[4] Choi, Y. J., Kim, S. H., Kang, S. H., Kim, S. Y., Kim, O. J., Yoon, C. H., Lee, H. Y., Youn, T. J., Chae, I. H., & Kim, C. H. (2019). Short-term effects of air pollution on blood pressure. Scientific Reports, 9(1), 1–8. https://doi.org/10.1038/s41598-019-56413-y

[5] Farzan, S. F., Howe, C. G., Chen, Y., Gilbert-Diamond, D., Cottingham, K. L., Jackson, B. P., Weinstein, A. R., & Karagas, M. R. (2018). Prenatal lead exposure and elevated blood pressure in children. Environment International, June, 1289–1296. https://doi.org/10.1016/j.envint.2018.10.049

[6] Fiedorowicz, H., Bartnik, A., Glazyrin, I., Diyankov, O., Jarocki, R., Krasnogorov, I., Koshelev, S., Kostecki, J., Loboda, P., & Szczurek, M. (2000). Generation of a laser plasma in result of interaction of a nanosecond laser pulse with a gas puff target. Proceedings of SPIE - The International Society for Optical Engineering, 3935(May), 2–5.

[7] Flynn, J. T., Kaelber, D. C., Baker-Smith, C. M., Blowey, D., Carroll, A. E., Daniels, S. R., De Ferranti, S. D., Dionne, J. M., Falkner, B., Flinn, S. K., Gidding, S. S., Goodwin, C., Leu, M. G., Powers, M. E., Rea, C., Samuels, J., Simase, M., Thaker, V. V., Urbina, E. M., … Okechukwu, K. (2017). Clinical practice guideline for screening and management of high blood pressure in children and adolescents. Pediatrics, 140(3). https://doi.org/10.1542/peds.2017-1904

[8] Fujii, H. (2013). Advanced material designs using friction stir welding technique. Progress in Advanced Structural and Functional Materials Design, 59–68. https://doi.org/10.1007/978-4-431-54064-9_5

[9] Height-for-age BOYS Height-for-age BOYS. (n.d.). 10–11.

[10] Height-for-age GIRLS Height-for-age GIRLS. (n.d.). 10–11.

[11] Kaczmarek, M., Stawińska-Witoszyńska, B., Krzyżaniak, A., Krzywińska-Wiewiorowska, M., & Siwińska, A. (2015). Who is at higher risk of hypertension? Socioeconomic status differences in blood pressure among Polish adolescents: a population-based ADOPOLNOR study. European Journal of Pediatrics, 174(11), 1461–1473. https://doi.org/10.1007/s00431-015-2554-0

[12] Khang, Y. H., & Lynch, J. W. (2011). Exploring determinants of secular decreases in childhood blood pressure and hypertension. Circulation, 124(4), 397–405. https://doi.org/10.1161/CIRCULATIONAHA.110.014399

[13] Kidy, F., Rutebarika, D., Lule, S. A., Kizza, M., Odiit, A., Webb, E. L., & Elliott, A. M. (2014). Blood pressure in primary school children in Uganda: A cross-sectional survey. BMC Public Health, 14(1), 1–9. https://doi.org/10.1186/1471-2458-14-1223

[14] Kilombero District. (2013). District Profile. 20–58.

[15] Lazarou, C., Panagiotakos, D. B., & Matalas, A. L. (2009). Lifestyle factors are determinants of children's blood pressure levels: The CYKIDS study. Journal of Human Hypertension, 23(7), 456–463. https://doi.org/10.1038/jhh.2008.151

[16] Liang, X., Xiao, L., Luo, Y., & Xu, J. (2020). Prevalence and Risk Factors of Childhood Hypertension in Urban-Rural Areas of China: A Cross-Sectional Study. International Journal of Hypertension, 2020. https://doi.org/10.1155/2020/2374231

[17] Muhihi, A. J., Njelekela, M. A., Mpembeni, R. N. M., Muhihi, B. G., Anaeli, A., Chillo, O., Kubhoja, S., Lujani, B., Maghembe, M., & Ngarashi, D. (2018). Muhihi-2018-Elevated blood pressure among prim.pdf. 1–8.

[18] Noubiap, J. J. (2020). Hypertension in children in sub-Saharan Africa: primordial prevention is crucial. The Pan African Medical Journal, 37(341), 341. https://doi.org/10.11604/pamj.2020.37.341.27387

[19] Placide Kambola, K., Emmanuel Kiyana, M., Clarence Kaut, M., Jaques Mbaz, M., Jeef Paul, B., Christian Ngama, K., Dophra Ngoy, N., & Olivier, M. (2021). Prevalence and associated factors of elevated blood pressure in adolescents in schools in Lubumbashi, Democratic Republic of Congo. Archives of Clinical Hypertension, 7, 001–006. https://doi.org/10.17352/ach.000029

[20] Review, A. S. (2021). Effects of Ambient Air Pollution on Blood Pressure Among Children and Adolescents : https://doi.org/10.1161/JAHA.120.017734

[21] Rindfleisch, A., Malter, A. J., Ganesan, S., & Moorman, C. (2008). Cross-sectional versus longitudinal survey research: Concepts, findings, and guidelines. Journal of Marketing Research, 45(3), 261–279. https://doi.org/10.1509/jmkr.45.3.261

[22] Roccella, E. J. (1996). Update on the 1987 task force report on high blood pressure in children and adolescents: A working group report from the national high blood pressure education program. Pediatrics, 98(4 PART 1), 649–658.

[23] Sesso, R., Barreto, P., Neves, J., & Sawaya, L. (2004). Malnutrition Is Associated with Increased Blood Pressure in Childhood. 900, 61–67. https://doi.org/10.1159/000078402

[24] Simonetti, G. D., Schwertz, R., Klett, M., Hoffmann, G. F., Schaefer, F., & Wühl, E. (2011). Determinants of blood pressure in preschool children: The role of parental smoking. Circulation, 123(3), 292–298. https://doi.org/10.1161/CIRCULATIONAHA.110.958769

[25] Size, D. S. (n.d.). Using Published Tables Using Formulas To Calculate A Sample Size Using A Census For Small Populations.