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Prehypertension, Hypertension and the Risk Factors in School-Age Children: An Exploratory Study

Ann Laughlin, PhD, RN, FAAN[#], Misty Schwartz, PhD, RN, Whitney Van De Graaff, MSN, RN, CPN, Jacquie Hanks, DNP, APRN-NP, Barbara Synowiecki, MSN, APRN, C-PNP, Susan Connelly, DNP, APRN-NP, CPNP, PC/AC

[#]College of Nursing, Creighton University, Nebraska, USA

[#]**Corresponding author:** Ann Laughlin, PhD, RN, FAAN. Professor, College of Nursing, Creighton University, 2400 California Plaza, Omaha, Nebraska 68178, USA

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Abstract

Background: The prevalence of hypertension in childhood has increased over the past decade. Purposes of this study were to examine prehypertension and hypertension in school aged children, the percentage of students who progressed from prehypertension to hypertension and to explore the relationship between economic health determinants in children in one midwestern community.
Methods: A partnership between a college of nursing and local schools served as the foundation for this study. A retrospective review of blood pressure readings, obtained through this partnership, served as the primary source of data.
Results: Comparing characteristics of the schools, there were statistically significant relationships between socio economic status and the incidence of hypertension. There was a strong positive correlation between the total percent incidence of hypertension and the school's overall percent below poverty level ($r = .808$, $p = .001$). There were also strong, negative correlations between both the total percent incidence of hypertension and median income and per capita income ($r = -.630$, $p = 0.21$; $r = -.783$, $p = .002$, respectively).
Conclusion: Schools with higher proportions of minority students had higher prehypertension and hypertension prevalence. Annual evaluation of BP in school age children is warranted to identify hypertension.

Keywords: Blood pressure; Children; Hypertension; Prehypertension; School screenings

Introduction

Evidence of the onset of essential hypertension in childhood has accrued since the initial report from the National Heart Lung and Blood Institute (NHLBI) in 1977. The report was updated in 2004 and was followed by the 2017 "Clinical Practice Guidelines for Screening and Management of High Blood Pressure in Children and Adolescents" [1]. The prevalence of hypertension in childhood, although comparatively low to that in adults, has increased over the past decade and influences the trajectory toward cardiovascular complications [2,3]. Higher blood pressure levels in childhood may progress into early onset hypertension in young adults and have also been shown to influence early childhood disease markers, including, but not limited to, left ventricular hypertrophy and carotid intimal medial thickness [4].

Differences have been reported in practice protocols as well as in provider attitudes and beliefs in the assessment, diagnosis, and treatment of childhood hypertension [5,6]. Emphasis on early identification of prehypertension in children and adolescents has been supported but not extensively studied; variability of measurement standards has also been reported [7,8]. Blood pressure data in these populations often are acquired across multiple settings and are not always consistently transferrable. Such settings may include primary or specialty care offices as well as community events such as school screenings.

Although the school environment is accepted as appropriate for collection of blood pressure data, the process of acquiring accurate readings is dependent on protocols, environment, equipment, and testers, all of which raise issues of reliability and validity [9,10]. Follow up for elevated blood pressure measurements varies, as it usually rests with parents and is dependent on their understanding of the potential healthcare consequences and investment in the need for further evaluation.

Intervention for hypertension is dependent upon consistent elevated readings according to standard protocols. Additionally, the point of intervention is influenced by identification of stages of hypertension and the rate of progression [11]. Reluctance of providers to intervene is not uncommon [12]. This hesitancy is often driven by the rationale that initial hypertension management should be directed towards Body Mass Index (BMI) reduction with lifestyle changes; pharmacological interventions may or may not follow.

The benefits of addressing hypertension in childhood can profoundly influence pediatric cardiovascular morbidity, mortality, and subsequent personal and societal costs. Such costs can present as active disease in childhood and follow individuals into adulthood [11]. Delay of action in general can adversely affect outcomes [12].

Background

Prevalence

Hypertension in children and adolescents is present in the United States (US) as well as in other areas of the world, occurring at rates similar to other diseases such as asthma or learning problems [13]. Estimates of pediatric hypertension based on the 2004 Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents was 2-4% of the population. The American Academy of Pediatrics (AAP) issued the new Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents in 2017, changing the diagnostic criteria for prehypertension and hypertension in children which led to an increase in diagnoses. The newest AAP guidelines from 2017 show prevalence of 16.3% of adolescents with prehypertension, 10.6% with Stage 1 hypertension, and 2.4% with Stage 2 hypertension [14].

Although there is a paucity of U.S. based studies on childhood hypertension, international research has been reported. Kaur, et al. [15], found that children in lower- and middle-income groups between the ages of 5-16 in India had high systolic blood pressure readings at a rate of 3.8% and 4.4%, respectively, as well as high diastolic blood pressure at a rate of 2.6% and 4%. Likewise, a survey of Chinese children found that high blood pressure in boys was present in 10.2% of the surveyed population and 8.9% in girls [16].

Obesity/High BMI and Hypertension

It is well-known that high BMI is closely related to the development of hypertension in the adult population. In fact, obesity and hypertension often have roots in childhood. According to Tu, et al. [17], as BMI in children exceeds the 85th percentile (for age and sex), there is a four-fold increase in prevalence of prehypertension and hypertension. BMI and elevated waist circumference are the best predictors of elevated blood pressure in children [18,19]. BMI is a routine measurement in schools and clinic settings, while waist circumference is rarely obtained.

Socioeconomic Status and HTN

Brummett, et al. [20] found that in a sample of 15,000 young adults, more than 62% had a systolic blood pressure greater than 120 mm Hg and more than 66% were classified as overweight. Lower household income was inversely related to blood pressure and obesity rates [20]. Higher education levels were indirectly linked to lower blood pressure levels due to correlation with “lower body mass, smaller waist circumference, and lower resting heart rate” [20].

The risk of undetected elevated blood pressure in children from low-income backgrounds has been documented in literature [21]. When health outcomes of U.S. children were compared to the higher income country of the Netherlands, U.S. children and adolescents were less healthy, and the authors identified fewer annual doctor and dental visits as a possible reason for the inequity. In both countries, low-income children had poorer health status when compared to their higher income counterparts [21]. Although there is a lack of research comparing health care access and childhood health outcomes, the 2013 Institute of Medicine report concluded the effects of unmet health care needs during childhood places the U.S. pediatric population at a healthcare disadvantage [22].

U.S. based studies discussing a relationship between Socioeconomic Status (SES) and hypertension in childhood are lacking. Interestingly, in one third-world country, an increased hypertension rate was associated with increased waist circumference and obesity in children with low and medium incomes [15]. A study performed in Iran noted that the region with highest SES had the lowest rate of high Blood Pressure (BP) and the region with the lowest SES had the highest rate of increased BP among students aged 6-18 years [23]. Similarly, a study performed in Poland found that SES of the parents had an impact on BP levels among adolescents [24]. Maternal education played a role in development of systolic pre-hypertension in those adolescents whose mothers were considered to have high/academic education level were “1.7 times less likely to develop systolic pre-hypertension” and “2.3 time less likely to develop diastolic pre-HTN” [24].

National Goals

Childhood hypertension often leads to adult hypertension and many chronic illnesses including heart disease, stroke, and diabetes [25,26]. The National Prevention Strategy [27], a plan put forth by the Surgeon General to promote a healthier America, has specifically addressed hypertension prevention among its goals. In addition, Healthy People 2030 has a goal to reduce the number of adults whose suffer from hypertension through prevention, detection, and treatment of risk factors [28]. Regarding the pediatric population, Healthy People 2030 has set a goal to reduction the proportion of children and adolescents with obesity, as obesity is linked to high blood pressure [28].

Long Term Implications

Many of the side effects of hypertension in children and adolescents, if untreated, will not be seen until adulthood. Early diagnosis and intervention of true hypertension in childhood can improve morbidity rates in adults [29]. Prehypertension treatment with antihypertensive medications improved outcomes in adults in The Treatment of Prehypertension Study (TROPHY) study [29]. Despite these results, Kaelber, et al. [5] found those with true hypertension and prehypertension were rarely diagnosed and medication guidelines were unlikely to be followed.

Long-term negative health implications in adulthood are associated with untreated high blood pressure in children and adolescents [30,31]. Longitudinal studies of blood pressures in children through adulthood reveal higher blood pressures in childhood are associated with hypertension later in life [11,32]. One in three adults in the U.S. has hypertension, which often predicts the severity of associated cardiovascular disease [30,31]. High blood pressure can lead to muscular hypertrophy which increases the risk for myocardial infarction and congestive heart failure [31,33]. Hypertension can also cause “stiffening” of blood vessels, leading to stroke and kidney failure [31,33]. Pediatric prehypertension and hypertension is an extremely complex issue facing healthcare providers today.

By identifying children with abnormal blood pressure levels at an early age, providers can be aware of the need for education and/or intervention and potentially reduce the progression to other long-term complications. The purpose of this exploratory study was to examine the prevalence of prehypertension and hypertension, the percentage of students who progressed from prehypertension to hypertension and to explore the relationship between blood pressure readings and economic health determinants in school-age children in one Midwest community.

Methods

Data for this study was obtained from students (first through sixth; and eighth grade) who received health screening services through a partnership agreement with a Midwest college of nursing (con). Thirteen schools were selected for inclusion in this analysis. All schools were private, without a school health nurse, and had been participants in the college of nursing’s school health program for several years. To examine data from diverse school populations, small (under 200 students) and large (over 500 students) schools were selected as well as schools located in low-, middle-, and high-income level neighborhoods. Although individual information was not collected related to socio-economic status, for the analysis, county census tract (zip codes) information was used as a proxy for income designation. Specific zip codes were described as low income if the income reported was equal to or below state and national poverty levels. Four of the 13 schools (31%) indicated that over 50% of their school population identified as minority, either black or Hispanic.

Procedure

All health screenings were performed by junior level nursing students under the supervision of nursing faculty, and the information was recorded on a paper screening sheet.

Screening data included age and sex and health parameters such as height, weight, BMI, BP, and vision, hearing, and dental health examinations. For purposes of this study, BP readings and BP percentiles were the specific variables of interest. Using the guidelines established by the AAP, students obtained a blood pressure reading for every child using a calibrated manual sphygmomanometer. Students were required to pass a BP “competency” check out prior to taking BPs in the school settings and were supervised by faculty during the screening process. If the child’s BP percentile was deemed high according to the guidelines, the BP was taken again after 15 minutes of rest and documented as a second reading. The high BP readings were recorded and flagged for a recheck/follow up on the rescreening day which usually occurred 2 to 3 weeks following the initial screening. This third value was recorded.

At the end of the screening day, each child’s sex, age, height, weight, and systolic and diastolic blood pressures were recorded to calculate BP percentile using the QuesGen application (https://www.quesgen.com). This online pediatric tool can assist providers in identifying children who are hypertensive (either a systolic or diastolic BP equal to or greater than the 95% based on the QuesGen calculation).

For this study, beginning with the academic school year 2018/2019, the BPs of children who were considered hypertensive (at or above the 95th percentile), based on QuesGen calculations were documented and then retrospectively examined each year going back to academic year 2011/2012. All BP readings for each academic school year as well as the BP percentiles were recorded in an excel spreadsheet along with screening date, grade, gender, age, height, weight, and BMI.

Data were analyzed using SPSS (v. 27). Descriptive statistics were calculated to evaluate the prevalence of pre-hypertension and hypertension, and percent of children who progressed from prehypertension to hypertension over seven years. Pearson product-moment correlation was used to explore the relationships of pre-hypertension and hypertension with other variables such as income, percent below poverty, and percentage of minority students within the school.

Further analyses were completed to compare health determinants of the schools, specifically those with the higher proportions of minority students (more than 50% Black and/or Hispanic) and SES. Since no individual SES data are collected on the students during school health screenings, we utilized the variable of SES using zip code as a SES proxy. Although there is no universally accepted definition of SES, individual-level SES has been generally calculated as a combination of income, education, and occupation. Zip code has been used in other studies as a way of generally measuring SES indicators and appears to be an adequate, although not perfect, proxy for individual SES [34]. For the purposes of this study, we specifically examined a combination of variables obtained by examining zip code data for each school including percent below poverty level, median income, and per capita income. The definitions of the SES variables are provided by the U.S. Census Bureau and are as follows: 1) Families are considered 'below poverty level' when their total income is less than the family's determined threshold. Because each family varies by size and composition, this percentage is calculated based on the family's size and composition and the thresholds which are updated every year by the Census Bureau [35]. This variable considered the percentage of families within the zip code that are considered below the poverty level. 2) Median income includes the income of the head of house and all individuals over 15 years of age in the household, whether they are related or not. 3) Per Capita income is the mean income computed for all individuals living within the home. It is calculated based on the total income of all those individuals and dividing that aggregate income by the total number of people.

Results

The original sample (N = 18,654; 50.4% male, 49.6 % female) included all BP readings from the school-age students screened from the 13 schools from the fall of 2011 to spring of 2018. Initially, the entire student body for each school was included and the overall prevalence of hypertension for the 13 schools for all seven years was 2.2% (SD ± 1.7) and prevalence of prehypertension was 1% (SD ± .84). Each school was then examined by year. The range of prehypertension prevalence per school was 0% to 5.8% of the population per year and the prevalence of hypertension in these schools ranged from 0% to 9% per year.

There were 322 children from the 13 schools categorized as hypertensive at some time during the seven years of screenings. Over half of those children (52%; n = 169) had at least one BP reading recorded as prehypertensive prior to a subsequent hypertensive reading. Also, of the 169 categorized as prehypertensive, 70 (41%) of those children also had a BMI equal to or greater than the 95th percentile categorized as obese. Lastly, 52% (n = 167) of the children who were classified as hypertensive, also had a BMI at or above the 95th percentile (obese).

Pearson Product-moment correlation coefficients found no statistically significant correlations in any of the schools between prehypertension prevalence and percent below poverty level; however, there were significant relationships between percent below poverty level and the prevalence of hypertension ($r = 0.808$, $n = 13$, $p = 0.001$). There were also strong, negative correlations between the prevalence of hypertension and both median income and per capita income ($r = -.630$, $p = 0.21$; $r = -.783$, $p = .002$, respectively).

As noted under description of participants, four of the 13 schools (31%) had indicated that over 50% of their school population identified as minority, either black or Hispanic. The additional variable of "High Minority" was created and schools were categorized as having more than half of their population as minority or not (coded as 0 or 1). There were no statistically significant relationships with 'High Minority' schools and prehypertension, but there were statistically significant relationships between these schools and hypertension ($r = .625$, $p = .022$) the percent below poverty level ($r = .694$; $p = .008$), and these schools also showed significant negative relationships with median income ($r = -.715$; $p = .006$) and per capita income ($r = -.751$; $p = .003$). Thus, those schools with higher minority populations had a higher prevalence of hypertension and are more likely to be below the poverty level. They also have a lower median income and lower per capita income.

Discussion

An established and innovative partnership between a college of nursing and local schools provided an opportunity to explore the prevalence of prehypertension and hypertension in school age children and examine risk factors that may impact its development. Contrary to what has been reported in the literature, the prevalence of prehypertension/hypertension in this sample was lower. However, consistent with the literature, there was an overlap/link between hypertension, BMI, minority status, and SES [33,17,36].

There is a gap in knowledge in the U.S. related to low SES and the development of hypertension in children; however, studies from other countries demonstrate a relationship between low-income status and hypertension [15,23]. In this study, higher prevalence of hypertension was demonstrated in schools that were in areas with high percentages of families living in poverty and those families with lower median and per capita incomes. Furthermore, hypertension was associated more often in those schools where over 50% of the school population were considered minority, and these specific higher minority schools also had lower median and per capita income, and more families below the poverty level [37,38].

Considering the increasing prevalence of hypertension and prehypertension in children and adolescence and the increasing risks associated with these diseases, focus must be directed towards the assessment, diagnosis, and intervention of the school-age population. The National High Blood Pressure Education Program, National Heart, Lung, and Blood Institute (NHLBI), American Academy of Family Physicians and the AAP 2017 policy statement recommend measuring BP in all children greater than 3 years of age although their recommendations vary regarding where they should be screened and the frequency of screening.

School-based health screenings may be one way to identify children with elevated BP especially among high-risk groups such as lower socioeconomic status and ethnically diverse populations. In a study recently conducted to determine the value of school-based BP screenings, researchers examined BP and BMI data from 4096 ethnically diverse and low-income students. Their findings showed that over 25% of the children had at least one elevated BP measurement and females and Hispanic children also had statistically significant higher readings. They conclude that since many low-income minority children lack healthcare access and when they do have appointments, are not being screened for BP, school-based BP screenings could ensure identification of high BP [36].

While annual evaluation of BP in school age children is warranted to identify and address hypertension, there is some evidence indicating that additional attention should be paid to the risk of prehypertension in this population as well. Findings from this study demonstrate that at least 50% of children who were considered hypertensive had at least one reading that was labeled as prehypertensive prior to a hypertensive reading. This outcome supports the need to pay close attention to children who have documented prehypertensive readings. Early identification is key but without timely referral and follow up the identification is insufficient. Nurses and other school health and wellness professionals are in an ideal position to use objective data from health screenings to discuss healthy lifestyle and behavior changes that may help prevent the development of hypertension with the children and their families. In addition, children who have a documented prehypertensive reading should have their blood pressure checked at more frequent intervals with the goal of early identification of hypertension.

Limitations and Strengths

This study has limitations, including missing readings over time due to children transferring schools and the absence of some children on screening or rescreening days. Because the CON did not collect individual race or income (SES) data, ethnicity and income information were determined and coded by school aggregate data. This strategy provided us with categories to interpret the data but also could disguise certain findings among minority groups and SES categories. Study strengths include the ability to take multiple BP readings in an environment familiar to the children, thus avoiding “white coat syndrome” (which is hypertension related to anxiety that occurs during a provider visit); the presence of nursing faculty to confer and validate with students if readings were noted to be very high or very low; and the documentation of readings over time. School health screenings are required in most states and having access to all students including those that are vulnerable or high risk makes the screenings even more important.

Conclusions

Since annual health screenings are required in most states, the school environment provides opportunities for nurses to incorporate BP readings into these events. School health screenings are an ideal event to assess and identify abnormal BP readings and utilize school health professionals to educate students and their parents on healthy lifestyle choices that may impact the development of hypertension over time.

Implication for Health

With the increasing occurrence of prehypertension and hypertension in school-age children, our findings emphasize the importance of prevention, early detection, and appropriate follow-through. Nurses and wellness professionals within the schools are key individuals that have access to large numbers of youth. Activities, such as school health screenings, are also crucial in the process of identification, especially those vulnerable children. School health professionals have consistent and ongoing interaction with children and families, providing them with a unique opportunity for documentation, referral, and follow-through.

Identifying children with elevated blood pressure levels at a young age will increase awareness of the increasing incidence of prehypertension and hypertension in children and the need for early blood pressure control to reduce the incidence of adult occurrence and complications caused from hypertension.

Considering the costs of hypertension in both the pediatric and adult literature, schools and school health screenings are an affordable way of accessing most school-age children regardless of access to providers, health insurance status, race, or SES.

For all schools but specifically those in low-income areas, implementing low-cost curricular and educational opportunities that involve promoting health-enhancing, behavioral changes in both the schools and family environment are critical. These activities should include information such as healthy eating and snack ideas and how to increase physical activity.

Human Subjects Approval Statement

This exploratory study was approved by the CON's University's Institutional Review Board.

Conflict of Interest Disclosure Statement

The authors declare no conflicts of interest.

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