Heliyon

Educational attainment modifies the association of wealth status with elevated blood pressure in the Ghanaian population

A. Kofi Amegah [a],*, **Simo Näyhä** [b]

[a] *Public Health Research Group, Department of Biomedical Sciences, School of Allied Health Sciences, University of Cape Coast, Cape Coast, Ghana*

[b] *Center for Environmental and Respiratory Health Research, Faculty of Medicine, University of Oulu, Oulu, Finland*

* Corresponding author.

E-mail address: aamegah@ucc.edu.gh (A.K. Amegah).

Abstract

The relationship between wealth and blood pressure (BP) in developing countries is unclear and it is important to understand how the socioeconomic environment influences BP in an African setting. Our objective was to determine the wealth differences in BP in the Ghanaian population and to clarify whether the relationship is modified by education level. Data from the 2014 Ghana Demographic and Health Survey was analyzed. A total of 9396 women and 4388 men were sampled nationwide and interviewed for the survey. Prevalence of hypertension in the population was low (10.4%). Systolic BP, diastolic BP, and odds of elevated BP increased with increasing wealth status. A linear trend was noted. Richest respondents recorded a 2.65 mmHg (95% CI: 1.09, 4.21) and 3.14 mmHg (95% CI: 1.97, 4.31) excess in systolic BP and diastolic BP, respectively and also, a 151% (AOR = 2.51, 95% CI: 1.80, 3.48) increased odds of elevated BP compared with the poorest. The wealth trend in BP was strongest among primary educated respondents (Interaction p = 0.0007). We found evidence of a consistent increase in elevated BP with increasing wealth status in

this African population, a trend that is contrary to what is seen in high income countries.

Keywords: Public health, Cardiology

1. Introduction

Hypertension is a major public health problem worldwide, contributing significantly to the global burden of heart disease, stroke, chronic kidney disease, other cardiovascular diseases, and premature mortality and disability [1, 2]. The estimated number of individuals with hypertension defined as systolic blood pressure (SBP) of 140 mmHg or higher increased from 442 million in 1990 to 874 million in 2015 with 7.8 million deaths (14% of all deaths) and 143 million disability adjusted life years (DALYs) in 2015 attributable to hypertension [2]. Hypertension also accounts for 41% of cardiovascular deaths, among which 40.1% are related to ischemic heart disease, 40.4% to cerebrovascular diseases, 38.1% to ischemic stroke and 42.5% to hemorrhagic stroke [2].

Hypertension disproportionately affects populations in low- and middle-income countries (LMIC) because of weak healthcare systems which results in poor treatment and control of blood pressure (BP) [1]. Increasing urbanization with its associated lifestyle changes including unhealthy dietary habits, increased alcohol use, smoking and low physical activity also drives hypertension levels in developing countries. In Sub-Saharan Africa, the estimated number of deaths attributable to hypertension almost doubled between 1990 and 2015, increasing from 243,000 to 467,300 deaths [2]. The number of DALYs related to hypertension in the region was estimated at 10.8 million in 2015. Prevalence of hypertension in the Sub-Saharan African region has been estimated at 30% [3]. In Ghana, the prevalence of hypertension continues to rise with the WHO Study on Global Ageing and Adult Health (SAGE) estimating the prevalence rate at 54.6% [4]. Hypertension is one of the most commonly reported health problems in Ghana and also, the dominant co-morbid condition in individuals with a chronic disease [4]. Hypertension ranks in the top five outpatient diseases in Ghana and also ranks as the third most common newly diagnosed outpatient disease among adults [5, 6].

Within populations, the burden of hypertension varies between socioeconomic groups. In high income countries, studies have consistently shown low socioeconomic status (SES) to be associated with increased prevalence of hypertension [7]. The relationship between SES and BP in LMICs is however unclear. In a review by Busingye and colleagues [8] that focused on evidence from rural populations of LMICs, the findings were mixed. Whereas no association was found in Africa, in East Asia an inverse association was found and in South Asia, a positive association

was noted. In Leng *et al.* [7] review, an inverse relationship was observed in Africa. Inconsistencies in the measurement of SES, sample heterogeneity, and differences in the degree of modernization and economic development have been proposed as possible reasons for the conflicting results emanating from developing countries [9, 10].

More epidemiologic studies investigating the relationship between indicators of SES and BP in developing regions are needed, particularly in Sub-Saharan Africa where a marked social and economic differences exist between and within countries, and also levels of hypertension and cardiovascular diseases (CVD) are increasing at an alarming rate. Such studies will provide insights into how the socioeconomic environment influences BP and help clarify inconsistencies in the literature. Also, empirical evidence on the cardiovascular health gaps between different social groups will become available and enable the development of intervention strategies to address the disparities in hypertension prevalence.

Our objective was therefore to ascertain whether BP and the prevalence of elevated BP in the Ghanaian population vary depending on wealth status and to further establish whether the relationship is modified by level of education. Identifying and elaborating on the potential effect modifiers of the wealth status − BP relationship is important for better tailoring intervention strategies in developing countries.

2. Materials and methods

Data from the 2014 Ghana Demographic and Health Survey (GDHS) [11], a nationally representative population-based survey was analyzed for this study. A two-stage sampling design was adopted by the 2014 GDHS and first involved the selection of 427 clusters consisting of enumeration areas delineated for the 2010 Population and Housing Census. These clusters were selected from the 10 administrative regions of the country and across urban (n = 216) and rural (n = 211) areas. The second stage involved the selection of about 30 households from each cluster resulting in a total sample size of 12,831 households.

Data collection was carried out using three questionnaires; household questionnaire, woman's questionnaire, and man's questionnaire. The household questionnaire was used to list all the members of and visitors to the selected households with the information gathered used to identify women and men eligible for individual interviews. Eligible participants must either be permanent residents of the selected households or visitors who stayed in the household the night before the survey. The woman's questionnaire was used to collect information from all eligible women aged 15−49 years. In half of the selected households, the man's questionnaire was administered to all eligible men aged 15−59 years. A total of 9396 women (response rate, 97.3%) and 4388 men (response rate, 95.2%) were interviewed for the survey.

2.1. Ascertainment of outcome

Three BP measurements were taken at intervals of 10 minutes or more from consenting women and men during the interviews using the LIFE SOURCE® UA-767 Plus digital oscillometric blood pressure monitor. The average of the second and third measurements was used to classify the respondents with respect to hypertension according to WHO guidelines [12]. Respondents with average systolic blood pressure (SBP) of ≥ 140 mmHg and average diastolic blood pressure (DBP) of ≥ 90 mmHg were classified as hypertensive. Respondents with normal BP measurement but reported at the time of the survey that they have previously been told by a physician that they have hypertension were also categorized as hypertensive.

2.2. Ascertainment of wealth status and educational attainment

Wealth index is used to measure inequalities in household characteristics and in the use of health and other services, as well as in health outcomes. According to the DHS program, it is an indicator of wealth that is consistent with expenditure and income measurement among households, and is constructed from household asset data using principal component analysis. The household assets include television, bicycle, or car, as well as dwelling characteristics, such as a source of drinking water, sanitation facilities, and type of flooring material. The wealth quintiles distinguished were the following: poorest, poorer, middle, richer and richest.

In the women and men questionnaires, respondents were asked whether they have ever attended school and if they answered "yes" they were further asked about the highest level of school they attended. The education categories were the following: none, primary (1−6 years of schooling), secondary (7−13 years of schooling) and higher (≥ 14 years of schooling).

2.3. Covariates

The core potential confounders adjusted in the analysis were gender, age, area of residence, religion, ethnic group and marital status of respondents. Body mass index (BMI) was available for only a subset of the study population. The survey collected anthropometric data (height and weight) for only respondents who were eligible for biomarker data collection. Also, among women respondents, those who were pregnant and those who had given birth in the two months preceding the survey were excluded from the BMI estimation. As a result, the dataset had no information on BMIs of more than half (55%) of the women and 14% of the men surveyed.

2.4. Statistical analysis

Linear regression modelling was used to estimate the effect of wealth status on SBP and DBP. Multivariable logistic regression adjusting for the potential confounders

was used to estimate the effects of wealth status on the prevalence of elevated BP. Respondents categorized as poorest served as reference in all the analysis. We tested for linear trend of the associations using the likelihood-ratio test.

Stratification analysis was conducted to elaborate the effect modifying role of level of education. We tested for interaction between wealth status and level of education by entering interaction terms into the models and performing the likelihood-ratio test.

We accounted for the two-stage sampling design in the analyses using the *svyset* function available in Stata 12.0 software to identify the survey design characteristics and prefixing all descriptive and estimation commands with *svy*.

2.5. Ethical approval

The 2014 GDHS was conducted under the scientific and technical supervision of the Ghana Statistical Service, Ghana Health Service (GHS), National Public Health Reference Laboratory of the GHS and Noguchi Memorial Institute for Medical Research. All the survey methods and procedures were carried out in accordance with relevant guidelines and regulations of these organizations. The survey protocols were approved by ICF International through The DHS Program. Informed consent was obtained from all subjects before the interview.

2.6. Data availability

The datasets analyzed for the study are available from the DHS program upon request.

3. Results

3.1. Characteristics of respondents

The characteristics of the study population are presented in Table 1. Females constituted about two-thirds (68%) of the respondents. About 16% of the respondents had no formal education with respondents educated up to higher (university/tertiary) level constituting 8%. About 16% of the respondents were categorized as poorest. Respondents categorized as richest constituted 24%.

3.2. Hypertensive status of respondents

Prevalence of hypertension in the population according to wealth status are presented in Table 2. The overall prevalence of elevated BP was found to be low (10.4%). About 62% of the hypertensive cases in the population was recorded among respondents categorized as richer/richest.

Table 1. Demographic and background characteristics of respondents (N = 13784).

Characteristic	Weighted n (%)
Gender[a]	
Male	4388 (31.8)
Female	9396 (68.2)
Age group (years)[b]	
15−19	2480 (18.0)
20−29	4394 (31.2)
30−39	3692 (26.8)
40−49	2699 (19.6)
50−59	519 (3.8)
Region of residence	
Western	1540 (11.2)
Central	1358 (9.9)
Greater Accra	2820 (20.5)
Volta	1057 (7.7)
Eastern	1306 (9.5)
Ashanti	2588 (18.8)
Brong Ahafo	1133 (8.2)
Northern	1142 (8.3)
Upper East	526 (3.8)
Upper West	314 (2.3)
Area of residence[c]	
Rural	6448 (46.8)
Urban	7336 (53.2)
Religion[d]	
Christian	10714 (77.7)
Moslem	2194 (15.9)
Traditional/Spiritualist	350 (2.5)
Other	4 (0.03)
No religion	521 (3.8)
Missing	1 (0.0001)
Ethnic group[e]	
Akan	6856 (49.7)
Ga/Dangbe	1122 (8.1)
Ewe	1861 (13.5)
Guan	303 (2.2)
Mole − Dagbani	2019 (14.7)
Grussi	382 (2.8)
Gurma	800 (5.8)
Mande	133 (1.0)

(*continued on next page*)

Table 1. (*Continued*)

Characteristic	Weighted n (%)
Other	307 (2.2)
Missing	1 (0.0001)
Marital status[f]	
Never married	4958 (36.0)
Married	5861 (42.5)
Cohabitation	1751 (12.7)
Widowed	283 (2.1)
Divorced	391 (2.8)
Separated	540 (3.9)
Education	
None	2261 (16.4)
Primary (1−6 years of schooling)	2262 (16.4)
Secondary/SHS (6−13 years of schooling)	8147 (59.1)
Higher (≥14 years of schooling)	1114 (8.1)
Occupation	
Unemployed	2801 (20.4)
Professional/Technical/Managerial	1053 (7.7)
Clerical	194 (1.4)
Sales	3832 (27.9)
Agriculture − Self employed	3041 (22.1)
Agriculture − Employed	99 (0.7)
Services	300 (2.2)
Skilled manual	1738 (12.6)
Unskilled manual	695 (5.1)
Missing	31 (0.002)
Wealth status	
Poorest	2263 (16.4)
Poorer	2416 (17.5)
Middle	2773 (20.1)
Richer	3077 (22.3)
Richest	3255 (23.6)
Body mass index (Kg/m^2, n = 9044)*	
Underweight (<18.5)	711 (7.9)
Normal (18.5−24.9)	5646 (62.4)
Overweight (25.0−29.9)	1762 (19.5)
Obesity (>29.9)	864 (9.6)
Unweighted population	61 (0.7)

Covariates: [a]Female, [b]15−29 years, [c]Rural, [d]Christian, [e]Northern tribe (Mole − Dagbani, Grussi, Gurma and Mande), and [f]Never married served as reference category.
*Population size is 8983.

3.3. Association of wealth status with blood pressure

The mean SBP and DBP (in mmHg) were low; 113.60 (SD = 16.93) and 74.50 (SD = 11.84), respectively. SBP and DBP increased with increasing wealth status with richest respondents recording a 2.65 mmHg (95% CI: 1.09, 4.21) and 3.14 mmHg (95% CI: 1.97, 4.31) increase in SBP and DBP, respectively (Table 3). Similar findings were observed in the sensitivity analysis, albeit, for SBP, the results were all not statistically significant (Table 4). For DBP, the likelihood-ratio test suggested evidence of a linear trend as the test was not statistically significant ($p = 0.1727$) and the estimate from the restricted model was statistically significant.

3.4. Association of wealth status with prevalence of hypertension

Odds of elevated BP increased with increasing wealth status with richest respondents found to have a 151% (AOR = 2.51, 95% CI: 1.80, 3.48) increased odds of elevated BP (Table 5). Similar findings were observed in the sensitivity analysis but with the effect estimates attenuated (Table 6). The likelihood-ratio test suggested evidence of a linear trend ($p = 0.1398$). The wealth status − BP relationship appears to be modified by education level of the respondents (Table 7). The interaction models confirmed the effect modifying potential of education (p = 0.0007). Primary educated respondents were found to have much higher increased odds of elevated BP across all the wealth categories. Secondary educated respondents were found to have lowest increased odds of elevated BP across all the wealth categories. The effect estimates noted for the higher educated respondents were also elevated with those categorized as poorer, recording the highest increased odds. All the effect estimates were, however, not statistically significant with the confidence intervals also noted to be very wide.

Table 2. Wealth status of respondents according to hypertensive status (N = 13784).

Wealth status	Hypertensive Weighted n (%)	Not hypertensive Weighted n (%)
Poorest	103 (7.2)	2160 (17.5)
Poorer	171 (11.9)	2245 (18.2)
Middle	269 (18.7)	2504 (20.3)
Richer	384 (26.7)	2693 (21.8)
Richest	508 (35.4)	2747 (22.2)
Total	1435 (10.4%)	12349 (89.6%)

Uncorrected Chi-square (X^2) value = 221.53, p < 0.0001.

Table 3. Linear regression of systolic and diastolic BP on wealth status (N = 13784).

Wealth status	Systolic BP (mmHg)		Diastolic BP (mmHg)	
	Unadjusted β (95% CI)	Adjusted β (95% CI)	Unadjusted β (95% CI)	Adjusted β (95% CI)
Poorest	Reference	Reference	Reference	Reference
Poorer	2.21 (1.24, 3.17)	0.94 (−0.11, 2.00)	1.85 (1.10, 2.60)	0.97 (0.14, 1.80)
Middle	3.51 (2.22, 4.79)	2.31 (1.06, 3.55)	3.08 (2.24, 3.92)	2.09 (1.23, 2.95)
Richer	4.38 (3.16, 5.60)	2.37 (0.98, 3.76)	4.41 (3.53, 5.29)	2.79 (1.75, 3.83)
Richest	5.62 (4.49, 6.76)	2.65 (1.09, 4.21)	5.50 (4.60, 6.41)	3.14 (1.97, 4.31)

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group and marital status.
Likelihood-ratio test for linear trend (SBP): $X^2 = 6.50$, df = 3, p = 0.0897.
Likelihood-ratio test for linear trend (DBP): $X^2 = 4.99$, df = 3, p = 0.1727.

4. Discussion

We found wealth status to be associated with BP in the Ghanaian population with SBP and DBP, and prevalence of elevated BP increasing consistently with increasing wealth status. In the sensitivity analyses, the associations persisted but were attenuated. Level of education modified the relationship with the increased odds of elevated BP found to be relatively high among primary educated respondents.

4.1. Validity issues

The sampling strategy of the 2014 GDHS survey together with the high response rate (97.3% and 95.2% for women and men, respectively) achieved minimizes selection bias. Also the standardized data collection instruments and procedures of DHS surveys including the present and the extensive training of interviewers guarantees the collection of reliable information from survey participants. Missing data was not a concern in this study. Of the variables of interest, only religion and ethnic group recorded one missing information.

The outcome of interest was measured three times at intervals of 10 minutes of more using the same BP monitor across all households and with the average of the second and third measurements used for our analysis. Interviewers were trained to use the device according to the manufacturer's recommended protocol and as a result, the potential for measurements errors is likely to be minimized. In classifying respondents with hypertension, the BP measurement was complemented with information on respondents who indicated at the time of the survey that they have previously being told by a physician that they have hypertension and were controlling their BP by one or more of the following measures; taking medication, controlling weight, decreasing salt intake, exercise, decreasing alcohol intake, and stopping smoking.

Table 4. Linear regression of systolic and diastolic BP on wealth status among participants with information on BMI (n = 9044).

Wealth status	Systolic BP (mmHg)		Diastolic BP (mmHg)	
	Unadjusted β (95% CI)	Adjusted β (95% CI)	Unadjusted β (95% CI)	Adjusted β (95% CI)
Poorest	Reference	Reference	Reference	Reference
Poorer	2.11 (0.99, 3.23)	0.37 (−0.93, 1.67)	2.06 (1.15, 2.96)	0.84 (−0.21, 1.88)
Middle	3.05 (1.77, 4.32)	1.16 (−0.36, 2.68)	2.83 (1.88, 3.78)	1.21 (0.05, 2.38)
Richer	4.71 (3.24, 6.18)	1.19 (−0.65, 3.03)	4.56 (3.53, 5.60)	1.67 (0.30, 3.03)
Richest	6.05 (4.63, 7.47)	1.23 (−1.10, 3.56)	6.07 (4.88, 7.26)	2.16 (0.37, 3.95)

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status and BMI.

Table 5. Binary logistic regression of elevated BP on wealth status (N = 13784).

Wealth status	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Poorest	1.00	1.00
Poorer	1.59 (1.23, 2.05)	1.34 (1.02, 1.76)
Middle	2.24 (1.73, 2.90)	1.82 (1.38, 2.40)
Richer	2.97 (2.31, 3.82)	2.22 (1.63, 3.03)
Richest	3.86 (3.03, 4.92)	2.51 (1.80, 3.48)

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group and marital status.
Likelihood-ratio test for linear trend: $X^2 = 5.48$, df = 3, p = 0.1398.

Table 6. Binary logistic regression of elevated BP on wealth status among participants with information on BMI (n = 9044).

Wealth status	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Poorest	1.00	1.00
Poorer	1.49 (1.11, 2.00)	1.18 (0.84, 1.64)
Middle	2.00 (1.49, 2.68)	1.55 (1.11, 2.16)
Richer	3.04 (2.27, 4.07)	2.03 (1.39, 2.95)
Richest	3.80 (2.87, 5.03)	2.12 (1.43, 3.13)

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status and BMI.

This approach enabled a better estimation of the prevalence of hypertension in the population. However, there are likely to be in this population, hypertensive cases who were diagnosed by people other than physicians notably herbalists, chemical sellers, pharmacists and medicine counter assistants, and possibly managing the condition with either orthodox or herbal medicines. In Sub-Saharan African countries including Ghana, antihypertensive drugs can be purchased without prescription.

Table 7. Binary logistic regression of elevated BP on wealth status stratified by level of education of respondents.

Wealth status	Level of education				
	Crude	None (n = 2261)	Primary (n = 2262)	Secondary (n = 8147)	Higher (n = 1114)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Poorest	1.00	1.00	1.00	1.00	1.00
Poorer	1.59 (1.22, 2.05)	1.99 (1.35, 2.94)	2.34 (1.37, 4.00)	1.20 (0.77, 1.88)	6.35 (0.67, 60.17)
Middle	2.24 (1.73, 2.90)	2.85 (1.83, 4.45)	4.24 (2.38, 7.54)	1.80 (1.22, 2.67)	2.17 (0.24, 19.62)
Richer	2.97 (2.31, 3.82)	2.96 (1.88, 4.67)	6.48 (3.41, 12.31)	2.50 (1.70, 3.66)	5.36 (0.65, 44.43)
Richest	3.86 (3.03, 4.92)	3.34 (1.59, 7.01)	7.72 (4.00, 14.91)	3.40 (2.33, 4.97)	6.19 (0.78, 49.18)

Likelihood-ratio test for interaction: $X^2 = 38.69$, df = 15, p = 0.000.

Unfortunately, the DHS survey do not capture these cases and could possibly lead to underestimation of hypertension in the population.

We were also not able to control for the confounding effect of physical activity, alcohol intake and consumption of salty foods, owing to the survey not collecting information on these covariates. The inability to control for these important potential confounders in the models is a threat to validity of the study results. However, the survey collected information on BMI, another important potential confounder, for a subset of the study population, and hence we conducted a sensitivity analysis restricting the analysis to this subsample to assess the robustness of the study findings. The consistent results produced from the sensitivity analysis further strengthen the study results.

4.2. Synthesis with previous evidence

The mean SBP and DBP in Ghana were found to be quite low (113.60 and 74.50 mmHg, respectively). Addo *et al.* [13] reviewed eleven population-based studies on hypertension conducted in Ghana and reported the mean SBP among women and men to range from 122.0 and 139.4 mmHg, and 123.8 and 132.9 mmHg, respectively. Mean DBP was reported to range from 68.8 and 86.4 mmHg among women, and 69.2 and 78.4 mmHg among men. The WHO SAGE study also reported the mean SBP and DBP for the Ghanaian population to be 137.4 mmHg and 90.5 mmHg, respectively [4]. We also found the prevalence of hypertension in Ghana to be low (10.4%) in contrast to the higher rates noted by Addo *et al.* [13] and the WHO SAGE study [4]. Addo and colleagues [13] reported the prevalence of hypertension to range from 19.3% in rural areas to 54.6% in urban areas. The WHO SAGE study reported the overall prevalence of hypertension to

be 54.6% with again, the rate higher in urban areas (60.5%) compared to rural areas (50.4%) [4].

The low hypertension prevalence recorded by the DHS survey is likely to have been underestimated owing to the use of interviewers who were non-clinicians for measuring BP of respondents, even though they were adequately trained. Roubsan-thisuk *et al.* [14] have suggested that compared to clinicians, trained personnel actually do underestimate the prevalence of hypertension. Also, as indicated earlier, the underestimation could be due to failure of the DHS survey to identify hypertensive cases diagnosed by people other than physicians. However, according to Addo *et al.* [13], almost all the studies they reviewed classified hypertension based on BP measurements taken during a single visit and hence the likelihood of overestimating the prevalence of hypertension.

We found odds of elevated BP to increase with increasing wealth status. Similar observations were reported by a study conducted in Bangladesh [15] that also relied on DHS dataset. The positive association between SES and hypertension in LMICs has been explained by the theory that rural-urban migration, economic prosperity and urbanization increases the prevalence of modifiable risk factors for hypertension such as overweight and obesity, sedentariness, and excessive caloric, fat, alcohol and salt intake as well as increased psychological stress, and interruption of traditional family links [16, 17]. This theory perfectly explains our findings. In Ghana, improvement in income and increased wealth, often leads to the adoption of unhealthy lifestyles that hinges around increased meat (kebab, fried pork) intake, increased patronage of restaurant and fast foods which are typically high in sodium and fat, increased alcohol consumption, and physical inactivity from vehicle ownership. Razak and Subramanian [18] have recommended the conduct of studies that better characterize the social and economic patterning of hypertension in LMICs to help advance our understanding of the burden of this condition in LMICs. This large, nationally representative study that provides evidence on the nature of the association between wealth status and hypertension in the Ghanaian population points in this direction and will assist in the implementation of strategies to control and prevent hypertension.

The higher increased odds of elevated BP noted across all wealth categories among primary educated respondents is somehow surprising. It is possible that these primary educated respondents were residing in poor neighborhoods with the findings possibly reflecting the adverse effects of poor neighborhood conditions on health. Residing in socioeconomically deprived neighborhoods is associated with increased risk of hypertension [19, 20]. The potential hypertension-inducing features of deprived neighborhoods include limited access to healthy food environment, and walking and exercise environment, as well as an excess of neighborhood stressors such as violence, crime, noise, crowding and poor social cohesion [21, 22]. There

is evidence linking neighborhood deprivation with risk factors for hypertension including higher BMI, smoking, poor diet and physical inactivity [23, 24, 25, 26] as well as noise and air pollution [27, 28, 29].

The higher increased odds of elevated BP among poorer higher-educated respondents is also surprising. It must, however, be emphasized that the effect estimate was imprecise and statistically not significant. The same deprived neighborhood hypertension-inducing effect could also explain this finding as it is possible these respondents were also residing in poor neighborhoods. Secondary educated respondents were found to have lowest increased odds of elevated BP across all the wealth categories and is a possible suggestion that, across all wealth categories, secondary education confers some cardiovascular health benefits. The reason for this, however, is difficult to speculate and we recommend that the explanatory factors are explored in future studies in this and similar populations to enable a better understanding of the distribution of hypertension in LIMCs.

5. Conclusions

In conclusion, we found evidence of wealth gradient in elevated BP in the Ghanaian population. The ongoing socio-demographic, epidemiological and nutrition transitions in Sub-Saharan African countries including Ghana which is characterized by increasing urbanization and changing lifestyle habits is a likely driver of the observed subgroup differences in hypertension. Health education for improved cardiovascular health in Ghana and similar African settings should target vulnerable sub-populations.

Declarations

Author contribution statement

A. Kofi Amegah: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Simo Näyhä: Analyzed and interpreted the data; Wrote the paper.

Funding statement

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

References

[1] WHO, A Global Brief on Hypertension: Silent Killer, Global Public Health Crisis, WHO, Geneva, Switzerland, 2013. http://ish-world.com/downloads/pdf/global_brief_hypertension.pdf. (Accessed 20 May 2016).

[2] M.H. Forouzanfar, P. Liu, G.A. Roth, M. Ng, S. Biryukov, L. Marczak, et al., Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990−2015, J. Am. Med. Assoc. 317 (2) (2017) 165−182.

[3] F. Ataklte, S. Erqou, S. Kaptoge, B. Taye, J.B. Echouffo-Tcheugui, A.P. Kengne, Burden of undiagnosed hypertension in sub-Saharan Africa: a systematic review and meta-analysis, Hypertension 65 (2) (2015) 291−298.

[4] R. Biritwum, G. Mensah, A. Yawson, N. Minicuci, Study on Global AGEing and Adult Health (SAGE) Wave 1, The Ghana National Report, World Health Organization, Geneva, Switzerland, 2013.

[5] W.K. Bosu, Accelerating the control and prevention of non-communicable diseases in Ghana: the key issues, Postgrad. Med. J. Ghana 2 (1) (2013) 32−40.

[6] Ministry of Health (MoH), National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana, MoH, Accra, Ghana, 2012.

[7] B. Leng, Y. Jin, G. Li, L. Chen, N. Jin, Socioeconomic status and hypertension: a meta-analysis, J. Hypertens. 33 (2) (2015) 221−229.

[8] D. Busingye, S. Arabshahi, A.K. Subasinghe, R.G. Evans, M.A. Riddell, A.G. Thrift, Do the socioeconomic and hypertension gradients in rural populations of low- and middle-income countries differ by geographical region? A systematic review and meta-analysis, Int. J. Epidemiol. 43 (5) (2014) 1563−1577.

[9] L.C.H. Fernald, N.E. Adler, Blood pressure and socioeconomic status in low-income women in Mexico: a reverse gradient? J. Epidemiol. Community Health 62 (5) (2008) e8.

[10] M.A. Mendez, R. Cooper, R. Wilks, A. Luke, T. Forrester, Income, education, and blood pressure in adults in Jamaica, a middle-income developing country, Int. J. Epidemiol. 32 (2003) 400−408.

[11] Ghana Statistical Service (GSS), Ghana Health Service (GHS), ICF International, Ghana Demographic and Health Survey 2014, GSS, GHS, and ICF International, Rockville, Maryland, USA, 2015.

[12] WHO, 1999 World Health Organization-International Society of Hypertension Guidelines for the management of hypertension: guidelines subcommittee, J. Hypertens. 17 (2) (1999) 151−185.

[13] J. Addo, C. Agyemang, L. Smeeth, A. de-Graft Aikins, A.K. Edusei, O. Ogedegbe, A review of population-based studies on hypertension in Ghana, Ghana Med. J. 46 (2 Suppl.) (2012) 4−11.

[14] W. Roubsanthisuk, U. Wongsurin, S. Saravich, P. Buranakitjaroen, Blood pressure determination by traditionally trained personnel is less reliable and tends to underestimate the severity of moderate to severe hypertension, Blood Press. Monit. 12 (2007) 61−68.

[15] E. Harshfield, R. Chowdhury, M.N. Harhay, H. Bergquist, M.O. Harhay, Association of hypertension and hyperglycaemia with socioeconomic contexts in resource-poor settings: the Bangladesh Demographic and Health Survey, Int. J. Epidemiol. 44 (5) (2015) 1625−1636.

[16] K.S. Reddy, N. Naik, D. Prabhakaran, Hypertension in the developing world: a consequence of progress, Curr. Cardiol. Rep. 8 (2006) 399−404.

[17] M.M. Ibrahim, A. Damasceno, Hypertension in developing countries, Lancet 380 (2012) 611−619.

[18] F. Razak, S.V. Subramanian, Commentary: socioeconomic status and hypertension in low- and middle-income countries: can we learn anything from existing studies? Int. J. Epidemiol. 43 (5) (2014) 1577−1581.

[19] M.L. Cathorall, H. Xin, A. Peachey, D.L. Bibeau, M. Schulz, R. Aronson, Neighborhood disadvantage and variations in blood pressure, Am. J. Health Educ. 46 (5) (2015) 266−273.

[20] P. Kaiser, A.V. Diez Roux, M. Mujahid, et al., Neighborhood environments and incident hypertension in the Multi-Ethnic Study of Atherosclerosis, Am. J. Epidemiol. 183 (11) (2016) 988−997.

[21] M.S. Mujahid, A.V. Diez Roux, J.D. Morenoff, et al., Neighborhood characteristics and hypertension, Epidemiology 19 (4) (2008) 590−598.

[22] B. Chaix, K. Bean, C. Leal, F. Thomas, S. Havard, D. Evans, B. Jégo, B. Pannier, Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study: which risk factors explain the associations? Hypertension 55 (3) (2010) 769−775.

[23] P.B. Ford, D.A. Dzewaltowski, Neighborhood deprivation, supermarket availability, and BMI in low-income women: a multilevel analysis, J. Community Health 36 (5) (2011) 785−796.

[24] J. Pearce, R. Barnett, G. Moon, Sociospatial inequalities in health-related behaviours, Prog. Hum. Geogr. 36 (2012) 3−24.

[25] C. Black, G. Ntani, R. Kenny, T. Tinati, M. Jarman, W. Lawrence, et al., Variety and quality of healthy foods differ according to neighbourhood deprivation, Health Place 18 (6) (2012) 1292−1299.

[26] P. Watts, G. Phillips, M. Petticrew, R. Hayes, C. Bottomley, G. Yu, et al., Physical activity in deprived communities in London: examining individual and neighbourhood-level factors, PLoS One 8 (7) (2013), e69472.

[27] A. Hajat, C. Hsia, M.S. O'Neill, Socioeconomic disparities and air pollution exposure: a global review, Curr. Environ. Health Rep. 2 (4) (2015) 440−450.

[28] L.M. Dale, S. Goudreau, S. Perron, M.S. Ragettli, M. Hatzopoulou, A. Smargiassi, Socioeconomic status and environmental noise exposure in Montreal, Canada, BMC Public Health 15 (2015) 205.

[29] A. Bocquier, S. Cortaredona, C. Boutin, A. David, A. Bigot, B. Chaix, J. Gaudart, P. Verger, Small-area analysis of social inequalities in residential exposure to road traffic noise in Marseilles, France, Eur. J. Public Health 23 (4) (2013) 540−546.