Socioeconomic status and hypertension in South African adolescents

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Background. Hypertension, a consistent elevation in both systolic and diastolic blood pressure, poses a global health challenge and likely develops early in life. Research suggests that socioeconomic status (SES) is associated with hypertension in childhood and adolescence. However, pathways through which SES leads to hypertension in adolescents remain unclear.
Objective. To examine the relationship between SES and hypertension among adolescents in South Africa (SA) and identify possible pathways linking SES and hypertension in this demographic group.
Methods. We analysed cross-sectional data from the South Africa Demographic and Health Survey 2016 comprising 1 062 adolescents aged between 15 and 19 years. SES was based on wealth quintiles. Multivariable logistic regression models and generalised structural equation modelling (GSEM) were employed to examine the relationship between SES and hypertension in adolescents.
Results. The unadjusted and adjusted relationships between SES and hypertension were not statistically significant. According to the GSEM, age (OR 0.72, 95% CI 0.63 - 0.82) and BMI (OR 1.06, 95% CI 1.02 - 1.11) were the only factors directly associated with hypertension. Being female had a significant indirect effect on hypertension (OR 1.18, 95% CI 1.03 – 1.36).
Conclusion. Although no association was observed between SES and hypertension, sex-specific patterns emerged among the correlates of hypertension. This emphasises a need for further social epidemiology research on hypertension in this age group, ideally incorporating other proxies of socioeconomic status besides the wealth index.

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Hypertension is a significant cause of premature mortality and disability globally and is a leading risk factor for cardiovascular disease.[1] A report from the World Health Organization (WHO) suggested that globally, 1 billion adults have hypertension, contributing to more than 9 million deaths annually. The rise in hypertension among adults worldwide is paralleled by an increase in hypertension within the younger population aged 15 to 30 years.[2] A recent meta-analysis reported an increase in the global prevalence of childhood hypertension from 1994 to 2018. According to this study in 2015, hypertension prevalence was 4.32% among 6-year-old children, 3.25% among 19-year-olds and peaked at 7.89% among 14-year-olds.[3] These findings were corroborated by a South African (SA) meta-analysis, revealing a prevalence of hypertension ranging from 7.5 - 22.3% in 2008.[4] Epidemiological studies in high- and low- to middle-income countries, including systematic reviews, meta-analyses and cross-sectional studies, have examined the prevalence of hypertension in children and adolescents globally and in SA.[5-7] These have also included attempts to estimate correlates of hypertension, such as sex, age and socioeconomic status (SES) in addition to biological, behavioural and metabolic factors.[8]

Of growing concern in low- to middle-income settings like SA, is the impact of socioeconomic gradients on blood pressure (BP) in children. Studies assessing the association between SES and hypertension report conflicting results, with some finding a link and others not. Kagura *et al*.[9] explored this relationship in Soweto, SA, and found no association between changes in SES and hypertension. Another study that analysed socioeconomic determinants of hypertension in SA suggested that it is a complex issue. In that study,[10] SES was defined by two variables, education and income, revealing contrasting results in male and female participants. For women, a higher SES was associated with lower BP, whereas in men, it correlated with a higher BP.[10] BP levels in adolescents may be influenced by their parents' SES through various pathways. These pathways include factors like maternal education level and paternal occupation status interlinked to the level of urbanisation of the place of residence. This takes into consideration age, sex and BMI status.[11]

Using data from the Demographic Health Survey 2016 provides an opportunity to estimate the prevalence and correlates of hypertension in adolescents in a nationally representative sample. In addition, there is potential to use a structural equation approach to understand the association between SES and hypertension in light of several correlates. Therefore, this study seeks to investigate direct and indirect pathways through which socioeconomic status leads to hypertension in the SA adolescent population.

Methods

Study design

Data for this study were obtained from the SA Demographic and Health Survey 2016 (SADHS 2016), which is a national survey carried out under the auspices of the National Department of Health. The survey sample was patterned to provide updated estimates of demographic and health indicators across the whole country's nine provinces, encompassing both urban and non-urban areas.[12] The SADHS 2016 comprised a sample of 8 514 women aged 15 - 49 years and 3 618 men aged 15 - 59 years. Interviews were conducted with women and men selected from all the households included in the survey.[12]

BP measurements were obtained using Omron 1300 digital BP monitors. These readings were taken at intervals of 3 minutes or more. Three readings were taken from each respondent. Each interviewing team comprised one nurse who underwent training in collecting biomarker data. This training consisted of lectures, demonstrations of biomarker measurement or testing procedures, exercises aimed at standardisation of height and weight measurements and practice with children at a health clinic.

Study population and sampling

The survey consisted of 2 227 SA adolescents aged 15 - 19 years. Of those, 1 090 did not have BP results, and only 1 137 participants were retained in the sample. Of the 1 137 participants, 59 individuals with a history of hypertension and 16 women who were pregnant at the time of the survey, were excluded. A total of 1 062 participants were included in this study.

Measures

Outcome variable

The outcome variable was hypertension. BP was classified according to the National High Blood Pressure Education Program (NHBPEP) working group on high BP in children and adolescents younger than 18 years.[13] Non-hypertensive participants were categorised based on a systolic or diastolic BP <90th percentile, while hypertensive individuals were classified by a BP ≥95th percentile. Among 18 and 19-year-olds, BP was classified according to the SA hypertension practice guideline 2014.[14] Non-hypertensive status was defined as a BP <120/80 mmHg, while hypertensive status was a BP ≥140/≥90 mmHg.[15,16]

Exposure variables

SES was the main exposure variable in this study. SES was kept as it was in the primary study (SADHS 2016), a categorical variable named 'wealth index' consisting of five quintiles. These quintiles are derived from a score given to each household based on their household possessions. The five quintiles were poorest, poorer, middle, richer and richest. Other covariates included were type of residence, marital status, level of education, cigarette use, household density, age, sex, BMI, diabetes status, and race/ethnicity.

Ethics considerations

Ethics approval for the study was obtained from the Human Research Ethics Committee (HREC) of the University of the Witwatersrand (ref. no. W-NN-200106-01).

Statistical analysis

Data were analysed using Stata version 16.0 (StataCorp., USA). To account for the study design of the DHS 2016 survey, survey-weighted data analysis was used in all models. Multivariable logistic regression was conducted to investigate the association between SES and hypertension, adjusting for age, sex and education. The pathways linking SES and hypertension were analysed using GSEM. The level of significance was set at an 0.05 for all analyses.

Results

Table 1 presents a hypertension prevalence of 26% in the study, which was higher in male (28.3%) compared with female (24.6%) participants. For hypertensive participants, the median SBP and DBP were 132 mmHg and 85 mmHg, respectively. For non-hypertensive participants, the median SBP and DBP were 116 mmHg and 73 mmHg, respectively. Of the participants, 69 (6.5%) were cigarette smokers, with 14 (29.3%) of them being hypertensive. Additionally, 85 (8.0%) participants were diabetic, and among them, 27.1% were hypertensive. The statistical analysis revealed significant effects of age (p<0.001), level of education (p=0.01), body mass index (BMI) (p=0.05) and glucose homeostasis (p=0.012) on the participants' hypertensive status.

Fig. 1 presents the sex-specific prevalence of hypertension across the five SES quintiles. The highest (35.5%) prevalence of hypertension among male participants was found in the poorer quintile, whereas the highest (32.1%) prevalence of hypertension was found in the poorest quintile among female participants. Prevalence fluctuated across sex and SES, with neither the top two nor the bottom two quintiles carrying the highest burden.

Table 2 presents the unadjusted (univariable) and adjusted (multivariable) ORs and 95% confidence intervals (CIs) obtained from logistic regression. Results from univariable models suggest that age (OR 0.72, 95% CI 0.64 - 0.81, p<0.001) and BMI (OR 1.05, 95% CI 1.01 - 1.08, p=0.013) were the only independent explanatory variables associated with hypertension status. Each additional year in age was associated with a 25% decrease in the likelihood of developing hypertension, whereas an increase in BMI by ≥1 kg/m^2 was linked to a 5% increase in the likelihood of developing hypertension.

The level of education had a borderline effect on hypertension status (OR 0.70, p=0.067). All five SES quintiles did not have a significant effect on hypertension status.

After adjusting for age, sex, BMI and level of education, SES had no significant effect on hypertension status. The marginal significance of the level of education on hypertension status was lost in the multivariate analysis. Age (OR 0.71, p<0.001) and BMI (OR 1.06, p=0.007) were the only two factors associated with hypertension status (Table 2).

Table 3 presents the indirect path through which SES affects hypertension-related factors (Fig. 2). The indirect effect of age was not significant, but the total effect remained statistically significant suggesting that with age, there is a 28% decreased risk of hypertension. The total effects of sex suggested that being female was associated with a 2% likelihood of being hypertensive, although this was not statistically significant. The total effects of all the SES quintiles were also not significant.

Discussion

In this study, hypertension had a prevalence of 26%. This is higher than the prevalence reported in previous studies, which indicated a prevalence of <10% among children and adolescents aged between 6 and 19 years.[3,17,18] The prevalence rate found in this study is closer to that of a systematic review conducted in SA, which reported a prevalence range of 7.5 - 22% for childhood hypertension.[19] In contrast, a recent meta-analysis conducted in India on childhood hypertension found a prevalence of 7%. The BP classification was based on a single measurement, therefore, the white coat effect may not be ruled out, which leads to an overestimation of hypertension in clinical settings.[20]

We did not find any direct or indirect association between SES and hypertension. This finding is consistent with other studies in SA and Brazil. Kagura *et al*.[9] investigated the effect of SES transition from low to high between childhood and adolescence in SA. Their findings indicated no association between SES transition from low to high between childhood and adolescence.[9] Similarly, Hallal *et al*.[21] in their study conducted in Brazil, found no association between SES change between childhood and adolescence.[21]

One of the possible explanations for our findings is that SES in the current study was derived from a score that was given to each household and was based on the household's assets. A meta-analysis by Leng *et al*.[22] used education as a measure of SES, which was not possible in adolescents as most are still in school. This may be the reason for the inconsistent findings. Nevertheless, our results are similar to previous findings showing that adolescents from low-

Table 1. Socio-demographic and anthropometric measures of the study participants

Variable	Hypertensive (*N*=281), *n* (%)	Non-hypertensive (*N*=781), *n* (%)	Total (*N*=1 062), *n* (%)	χ^2	*p*-value
Age in years				39.9	
15	72 (33.8)	141 (66.2)	213 (20.1)		<0.001***
16	83 (34.6)	157 (65.4)	240 (22.6)		
17	62 (30.4)	142 (69.6)	204 (19.2)		
18	30 (14.2)	181 (85.8)	211 (19.9)		
19	34 (17.5)	160 (82.5)	194 (18.3)		
Sex				1.8	
Male	152 (28.3)	386 (71.8)	538 (50.7)		0.179
Female	129 (24.6)	395 (75.4)	524 (49.3)		
Race					
Black	253 (26.0)	719 (74.0)	972 (91.5)		0.425†
White	3 (18.8)	13 (81.3)	16 (1.5)		
Coloured	23 (33.8)	45 (66.2)	68 (6.4)		
Indian/Asian	2 (33.3)	4 (66.7)	6 (0.6)		
SES				4.4	
Poorest	79 (28.8)	195 (71.2)	274 (25.8)		0.350
Poorer	63 (27.8)	164 (72.3)	227 (21.4)		
Middle	58 (22.5)	200 (77.5)	258 (24.3)		
Richer	61 (28.6)	152 (71.4)	213 (20.1)		
Richest	20 (22.2)	70 (77.8)	90 (8.5)		
Type of residence				0.8	
Urban	132 (27.9)	342 (72.2)	474 (44. 6)		0.357
Rural	149 (25.3)	439 (74.7)	588 (55.4)		
Marital status					
Never married	279 (26.6)	771 (73.4)	1050 (98.9)		0.807†
Married	2 (18.2)	9 (81.8)	11 (1.0)		
Divorced/Separated	0	1 (100)	1 (0.1)		
Education				5.5	
Primary	69 (32.9)	141 (67.1)	210 (19.8)		0.019**
Secondary	212 (24.9)	640 (75.1)	852 (80.2)		
BMI (kg/m^2)					
<18.5	57 (28.0)	191 (77.0)	248 (23.4)		0.053†*
18.5 - 24.9	166 (26.5)	461 (73.5)	627 (59.0)		
25.0 - 29.9	33 (28.0)	85 (72.0)	118 (11.1)		
>29.9	19 (31.7)	42 (68.3)	60 (5.7)		
Missing	6 (66.7)	3 (33.3)	9 (0.9)		
Average blood pressure, median (IQR)					
SBP	132 (17)	116 (14)	119 (17)		
DBP	85 (10)	73 (10)	76 (12)		
Household density, median (IQR)	5 (3)	5 (3)	5 (3)		
Smoke cigarette				1.4	
Yes	14 (20.3)	55 (79.7)	69 (6.5)		0.230
No	267 (26.9)	726 (73.1)	993 (93.5)		
Diabetes status				11.0	
Normal	27 (20.2)	107 (79.9)	134 (12.6)		0.012*
Prediabetic	174 (25.4)	512 (74.6)	686 (64.6)		
Diabetic	23 (27.1)	62 (72.9)	85 (8.0)		
Missing	57 (36.3)	100 (63.7)	157 (14.8)		

SES = socioeconomic status; BMI = body mass increase; IQR = interquartile range; SBP = systolic blood pressure; DBP = diastolic blood pressure.
*$p<0.05$
**$p<0.01$
****$p<0.001$
χ^2 analysis was conducted to compare outcomes.
†Fisher's exact test was performed to compare outcomes.

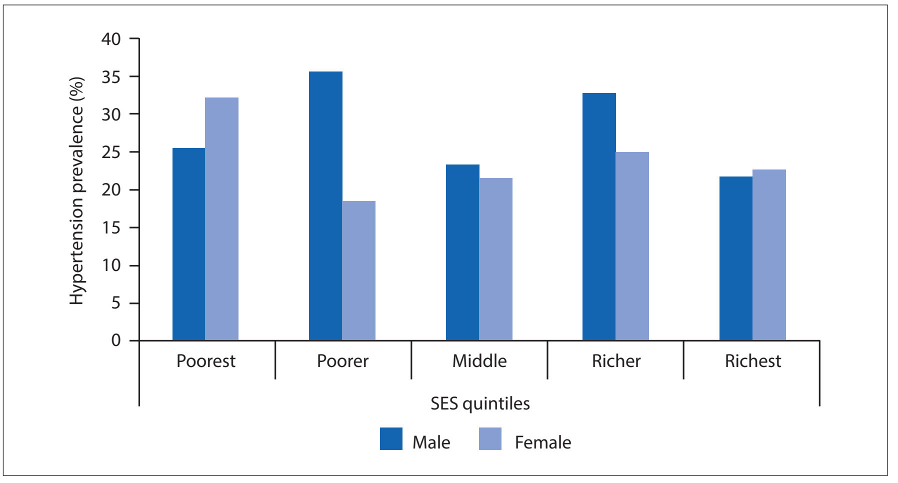


Fig. 1. Sex specific prevalence of hypertension in South African adolescents across socioeconomic status quantiles

income settings had higher BP levels despite having a normal weight. In our study, the prevalence of hypertension was high, and many were undiagnosed. This finding aligns with results from a study that was conducted on paediatric patients in North Carolina.[23]

The total effects of age showed no variation and revealed decreased odds of hypertension in this study. Conversely, a meta-analysis conducted by Leng *et al.*[22] reported that an increase in age resulted in an increased risk of hypertension. Studies have shown that the prevalence of hypertension is higher among adults than in adolescents.[22] For instance, a study[18] conducted in SA in 2017 reported a high (42 - 54%) prevalence of hypertension.

Table 2. Results from the univariable and multivariable logistic regression of hypertension and factors examined

Variable	Univariable (OR (95 % CI))	*p*-value	Multivariable (OR (95 % CI))	*p*-value
Age	0.72 (0.64 - 0.81)	<0.001***	0.71 (0.63 - 0.81)	<0.001***
Sex				
Female	0.96 (0.67 - 1.37)	0.818	0.82 (0.54 - 1.23)	0.328
Male	Ref			
Race				
Black/African	Ref			
White	0.50 (0.08 - 3.24)	0.465	-	
Coloured	1.40 (0.67 - 2.94)	0.375	-	
Indian/Asian	1.33 (0.15 - 12.11	0.801	-	
SES				
Poorest	1.20 (0.74 - 1.95)	0.453	1.20 (0.72 - 1.98)	0.486
Poorer	1.25 (0.77 - 2.03)	0.364	1.18 (0.71 - 1.96)	0.518
Middle	Ref		Ref	
Richer	1.02 (0.61 - 1.72)	0.930	1.00 (0.58 - 1.73)	0.999
Richest	0.72 (0.32 - 1.64)	0.439	0.68 (0.30 - 1.55)	0.358
Type of residence				
Urban	Ref			
Rural	1.13 (0.79 - 1.60)	0.508	-	
Marital status				
Never married	Ref			
Married	0.64 (0.12 - 3.44)	0.601	-	
Divorced/Separated	†			
Education				
Primary	Ref		Ref	
Secondary	0.70 (0.47 - 1.03)	0.067	0.98 (0.65 - 1.47)	0.907
BMI (kg/m2)	1.05 (1.01 - 1.08)	0.013*	1.06 (1.02 - 1.11)	0.007**
Use of tobacco	1.03 (0.99 - 1.08)	0.133	-	
Household density	1.00 (0.94 - 1.06)	0.901	-	
Diabetes status				
Normal	Ref			
Prediabetic	1.28 (0.75 - 2.18)	0.370	-	
Diabetic	1.25 (0.60 - 2.58)	0.547	-	

OR = odds ratio; CI = confidence interval; Ref = reference; SES = socioeconomic status; BMI = body mass index.
*p<0.05
**p<0.01
***p<0.001
- Denotes that that variable was not selected for the multivariate analysis in the stepwise forward selection and was not included in the final model.
†Indicates that no participant in that group was hypertensive, thus, no estimations were found.

Another study in SA involving adolescents in their final year of high school reported a prevalence of 13.7%.[17] BMI has a significant effect on hypertension. Our analysis results showed a 5% increased risk of hypertension for every unit increase in BMI. Notably, previous studies found similar results showing that BMI is an important risk factor for hypertension.[24,25] Similarly, another study among adolescents showed a moderate increase in both SBP and DBP with an increase in BMI percentiles.[26]

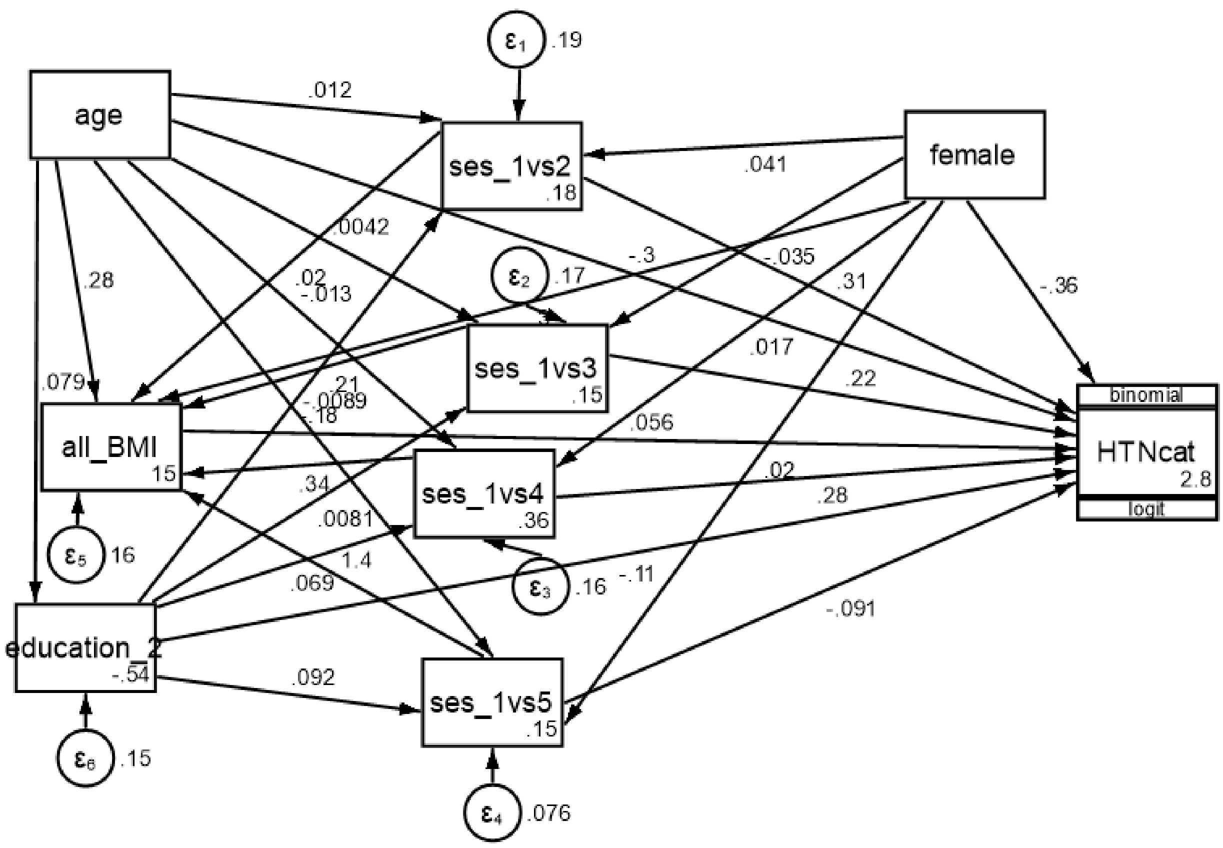
Conclusion

This study found a high prevalence of hypertension in SA adolescents, which falls within the prevalence ranges reported in previous studies within the region. Surprisingly, there was no association between SES and hypertension, indicating that the wealth index may not be a sensitive predictor of SES in this age group. As such, further studies are required to assess other SES-related factors. Further, longitudinal studies are needed to elucidate

Table 3. GSEM results showing the ORs for indirect effects, direct effects, and total effects from the indirect path analysis

Variable	Indirect effects; OR (95% CI)	Direct effects; OR (95% CI)	Total effects; OR (95% CI)
Age	1.01 (0.98 - 1.05)	0.71 (0.6 - 0.81)	0.72 (0.63 - 0.82)
Sex (female)	1.18 (1.03 - 1.36)	0.82 (0.54 - 1.23)	0.98 (0.67 - 1.39)
SES			
Poorest	0.98 (0.92 - 1.03)	1.20 (0.72 - 1.98)	1.17 (0.70 - 1.95)
Poorer	1.00 (0.94 - 1.06)	1.18 (0.72 - 1.95)	1.18 (0.71 - 1.97)
Middle	Ref	Ref	Ref
Richer	1.00 (0.94 - 1.07)	1.00 (0.58 - 1.73)	1.00 (0.58 - 1.73)
Richest	1.04 (0.94 - 1.16)	0.92 (0.49 - 1.74)	0.71 (0.31 - 1.65)
BMI (kg/m^2)	-	1.06 (1.02 - 1.11)	1.06 (1.02 - 1.11)
Education (secondary)	0.92 (0.82 - 1.04)	0.98 (0.65 -1.47)	0.90 (0.60 - 1.35)

OR = odds ratio; CI = confidence interval; SES = socioeconomic status; Ref = reference; BMI = body mass index.



Variables: female, BMI (all_BMI), age, SES poorest quintile (ses_1vs), SES poorer quintile (ses_1vs3), SES richer quintile (ses_1vs4), SES richest quintile (ses_1vs5), secondary education, (education_2).
BMI = body mass index; SES = socioeconomic status.

Fig. 2. The indirect path analysis diagram of the different factors on hypertension displayed using generalised structural equation modelling

the relationship between SES and the onset of hypertension in adolescents.

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