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3 1 **Social Epidemiology of Hypertension in Buffalo City Metropolitan Municipality**
4 2 **(BCMM): Determinants of Prevalence, Awareness, Treatment and Control among**
5 3 **South African Adults**

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46 32 **Keywords:** Blood Pressure Control, Diabetes mellitus, Hypertension, Obesity, South Africa

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48 34 5 tables and 1 figure

35 Abstract

36 **Objectives:** Epidemiological data on prevalence, awareness, treatment and control of blood
37 pressure are scarce in Buffalo City Metropolitan Municipality (BCMM), South Africa is
38 scarce. We therefore examined hypertension prevalence, awareness, treatment, control and
39 their determinants among adults attending health facilities in BCMM.

40 **Design:** A cross-sectional analytical study.

41 **Settings:** Three largest out-patient clinics in BCMM.

42 **Participants:** Ambulatory adults (18 years and above) attending the study settings during the
43 study period (n=998).

44 **Primary outcome measure:** Prevalence of hypertension (systolic BP of ≥ 140 mmHg and/or a
45 diastolic BP of ≥ 90 mmHg or current medication for hypertension), awareness (prior
46 diagnosis of hypertension), treatment and control (Eight Joint National Committee Criteria of
47 blood pressure $< 140/90$ mmHg).

48 **Secondary outcome measure:** Associated factors of hypertension, unawareness and
49 uncontrolled hypertension.

50 **Results:** Of the 998 participants included, the prevalence of hypertension was 49.2%.
51 Hypertension unawareness was reported by 152 participants (23.1%) with significant gender
52 difference ($p=0.005$). Higher monthly income, single status, age less than 45 years,
53 unemployment, current cigarette smoking, alcohol usage, absence of diabetes and non-obese
54 were significantly associated ($p<0.05$) with hypertension unawareness.

55 Of the participants who were aware (n=339), nearly all (93.1%, n=311) were on anti-
56 hypertensive medications and only 131 participants (42.1%) achieved blood pressure
57 treatment target. In the multivariate logistic regression model analysis, aging (95%CI 1.9 to
58 4.4), being married (95%CI 1.0 to 2.0), male sex (95%CI 1.2 to 2.3), concomitant diabetes
59 (95%CI 1.9 to 3.9), lower monthly income (95%CI 1.2 to 2.2), being unemployed (95%CI
60 1.0 to 1.9) and central obesity (95%CI 1.5 to 2.8) were the significant and independent
61 determinants of prevalent hypertension.

62 **Conclusion:** Prevalence and awareness of hypertension was high in the study population.
63 However, the sub-optimal control of blood pressure among treated individuals as well as the
64 significant cardiovascular risk factors warrants attention of health authorities of BCMM and
65 the country.

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68 Strengths and limitations of the study

- 69 • Large sample size of participants.

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3 70 • **First epidemiological data on hypertension prevalence, awareness,**
4 **treatment and control in BCMM.**
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6 72 • **Survey was conducted in the three largest out-patient clinics.**
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8 73 • **Findings should be treated with caution in view of the cross-sectional**
9 **design and convenience sampling.**
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76 Introduction

77 Cardiovascular diseases (CVD) are the leading cause of death (17.3 million deaths)
78 worldwide with a steep increase, especially in the developing countries, with 80% death toll
79 prevalence.¹ Cardiovascular diseases have been predicted to account for about 23.6 million
80 deaths by 2030.² Hypertension is the most important modifiable risk factor for cardiovascular
81 diseases and an independent risk factor for mortality worldwide³⁻⁶ and is been described as a
82 silent killer and a dangerous disease due to its asymptomatic nature among the sufferers.⁷
83 About nine million people die from hypertension annually.⁸

84 The prevalence of hypertension in Africa has been reported in several studies.⁹⁻¹²
85 Hypertension usually considered a disease of affluence, is now prevalent among the poor.¹³
86 In 2012, one in three adults were reported to be hypertensive with the highest prevalence
87 recorded in Africa (50%).¹⁴ South Africa is facing a serious burden from hypertension.¹⁵
88 More than 6.2 million South Africans are hypertensive; 3.2 million have blood pressure
89 higher than 160/90mmHg and about 53 men and 78 women die daily from the effect of
90 hypertension.¹⁶ Considering the pace of economic growth in South Africa, a further increase
91 in the prevalence of hypertension is expected if drastic actions are not implemented in the
92 country.^{17,18} Treatment and control of hypertension are associated with reduced incidence of
93 complications, such as stroke, coronary heart disease and kidney disease.¹⁹⁻²¹

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95 While the majority of individuals with hypertension remain undiagnosed, there is evidence
96 supporting the sub-optimal control of blood pressure among individuals in care for
97 hypertension in South Africa.²²⁻²⁵ Many reasons have been advanced for the sub-optimal
98 treatment outcomes, such as socio-economic and behavioural factors and health system
99 factors.^{22,26-28}

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3 101 In sub-Saharan Africa, the burden of hypertension is worsened by unreliable epidemiologic
4 102 data, under-diagnosis, poor treatment and uncontrolled hypertension.²⁹⁻³¹ Epidemiologic data
5 103 helps to inform public health policies for the prevention and control of hypertension burden.³²
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7 104 Likewise, prevention strategies, increased awareness, prompt detection, adequate treatment
8 105 and control of blood pressure are basic requirements for a comprehensive approach for the
9 106 reduction of hypertension, its complications and ultimately, the associated morbidity and
10 107 mortality.³³
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16 109 There is paucity of data on the prevalence, awareness and control of hypertension in Eastern
17 110 Cape, an understudied province in South Africa. Such a vital epidemiological data will
18 111 inform policies on non-communicable diseases, resource distribution and crafting effective
19 112 interventions. Therefore, this study bridges the gap by determining the prevalence and
20 113 associated factors of hypertension, awareness and controlled hypertension among adults
21 114 attending the three largest out-patient clinics in the Buffalo City Municipality, Eastern Cape,
22 115 South Africa.
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30 31 117 **Methods**

32 33 118 **Study area and design**

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35 119 This study analysed data from the Buffalo City Metropolitan Municipality (BCMM) Non-
36 120 Communicable Disease Surveillance study. Briefly, we selected the three largest out-patient
37 121 clinics serving the residents of Buffalo City Municipality, South Africa. These clinics provide
38 122 primary health care services for the 755,200 residents of Buffalo City Municipality of Eastern
39 123 Cape Province.³⁴ The family medicine outpatient clinic of Cecilia Makiwane hospital and
40 124 Nontyatyambo community health centre provide primary health care services to the
41 125 predominant black South African residents of Mdantsane Township, a semi-urban
42 126 community of Eastern Cape and Empilweni-Gompo community health centre situated in
43 127 Duncan Village, a suburban community of East London.
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50 51 128 **Participants and Sample size**

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53 129 The sample size of the Buffalo City Metropolitan Municipality (BCMM) Non-Communicable
54 130 Disease Surveillance study was based on the estimated proportion of individuals with
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3 131 hypertension in the population. The appropriate sample size was estimated using the
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5 132 following formula:

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$$N = (Z_{1-\alpha})^2 * (P (1 - P)) / D^2$$

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9 134 Where Z is the confidence level, P is the expected proportion of individuals with
10 135 hypertension, and D is the margin of error. P was set at 0.40 and D at 0.05. The calculation
11 136 was performed at the 95% confidence level. The required sample size per study site was 369
12 137 participants and a total of 1107 participants were included in the study. All ambulatory
13 138 individuals (patients and their family members) who fulfilled the inclusion criteria and
14 139 attending the study settings during the period of study were recruited into the study. All
15 140 participants with abnormal findings agreed to be evaluated by the clinicians at the study
16 141 settings. This study was conducted in April-May, 2016.

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23 142 **Eligibility criteria**

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25 143 Participants were included if age \geq 18 years, attending the out-patient clinics of the selected
26 144 hospital and community health centres, willing to participate and had fasted in the preceding
27 145 eight hours prior to recruitment into the study. Exclusion criteria include acutely ill,
28 146 psychotic, debilitated, pregnant or handicapped in any form such that obtaining
29 147 anthropometric measurement would be difficult. Consecutive sample of 1107 participants
30 148 took part in the study.

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36 149 **Study instrument**

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38 150 The participants were interviewed using the previously validated WHO STEPwise
39 151 questionnaire³⁵ which comprises three major items; demographic and behavioural data, and
40 152 measurements.

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44 153 **Ethical approval**

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46 154 Ethical approval was obtained in accordance with Helsinki II Declaration from the University
47 155 of Fort Hare Research Ethics Committee and the Eastern Cape Department of Health. The
48 156 management of the sub-district department of health as well as the head of the respective
49 157 health facilities gave permission prior to data collection. All participants provided written
50 158 informed consent to participate in this study.

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55 159 **Data collection procedure**

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3 160 Data were obtained by personal interview on demographic and behavioural characteristics
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5 161 and measurements of blood pressure, blood glucose and anthropometric parameters.
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7 162 Demographic variables included items on sex, age, marital status, level of education,
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9 163 employment status and average monthly income earning. The socioeconomic factors were
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11 164 measured by assessing the average monthly income, level of education and employment
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13 165 status. Participants were categorised as low income earners if they earned R2000 or less per
14
15 166 month and middle income earners if they earned more than R2000. Level of education was
16
17 167 obtained by self-reporting of the highest grade level attained in school and were categorised
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19 168 as having no formal education, primary (grade 1-7), secondary (grade 8-12) or tertiary (post-
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21 169 secondary). Participants were defined as unemployed if they reported that they were not
22
23 170 employed in both formal and informal sectors.

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25 171 The following behavioural variables were obtained by self-reporting; cigarette smoking,
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27 172 alcohol use, physical activity, and fruit and vegetables consumption patterns. Participants
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29 173 were questioned on their servings of fruit and vegetables daily. The smoking categories
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31 174 include; primary smokers (smoking directly) or secondary smokers (if living with a smoker)
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33 175 or non-smoker. Physical activity level of participants were obtained by self-reporting and
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35 176 categorised based on their engagement in moderate (yes/no) or vigorous intensity (yes/no)
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37 177 exercise leading to an increase in heart rate and respiratory rate such as gardening.

38 178 **Measurements**

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40 179 Blood pressure (systolic and diastolic) was measured in accordance with standard protocols³⁶
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42 180 with a validated Microlife BP A100 Plus model. Hypertension was defined as average of two
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44 181 systolic blood pressure of ≥ 140 mmHg and diastolic of ≥ 90 mmHg in accordance with the
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46 182 Eight Joint National Committee (JNC 8). Participants who reported being informed of their
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48 183 hypertensive status by health professional(s) were considered aware. Uncontrolled
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50 184 hypertension among those on treatment with at least one or more anti-hypertensive
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52 185 medications was defined as systolic blood pressure greater than or equal to 140mmHg and
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54 186 diastolic blood pressure greater than or equal to 90mmHg in accordance with the Eight Joint
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56 187 National Committee Report (JNC 8). Fasting blood glucose of each participant was measured
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58 188 with a validated ACCU-CHEK glucose monitoring apparatus in fasting state. Participants
59
60 189 were diagnosed of having diabetes if their fasting blood glucose equal or greater than 7.0
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191 190 mmol/L or current medications for diabetes and they were defined as having pre-diabetes if
the fasting blood glucose falls between 6.1-6.9 mmol/L.³⁷

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3 192 Body weight was measured in light clothes to the nearest 0.01kg in the standing position
4 193 using a Soehnle Scale (Soenle-Waagen Gmbh Co., Muurhardt, Germany) and height was
5 194 measured to the nearest 0.1m by stadiometer in standing position with closed feet (without
6 195 shoes), holding their breath in full inspiration and Frankfurt line of vision.³⁸ Body mass index
7 196 (BMI) was calculated as weight in kg divided by height in square metres (kg/m²). BMI was
8 197 categorized in accordance with WHO³⁹ as <18.5kg/m², 18.5-24.9kg/m², 25.5-29.9kg/m² and
9 198 >30.0kg/m² as underweight, normal, overweight and obese, respectively.

15 199 **Statistical analysis**

17 200 Data were expressed as mean values ± standard deviations (SD) for continuous variables.
18 201 Counts (frequencies=n) and proportions (%) were reported for categorical variables.
19 202 Percentages were compared using Chi-square test. The bivariate and multivariate logistic
20 203 regression were used to identify the significant associated factors of hypertension and their
21 204 95% confidence interval (95% CI). The logistic regression was also adjusted for confounding
22 205 factors. Statistical analyses were performed with the Statistical Package for Social Science
23 206 (SPSS) version 21 for windows (SPSS Inc., Chicago, IL, USA) and p-value < 0.05 were
24 207 considered statistically significant.

31 208 **Results**

33 209 We excluded 109 participants with incomplete data. Of the 988 included in our analysis; 321
34 210 were males and 677 were females. More than half of the respondents; 56.5% and 60.2% were
35 211 between the ages of 18 and 45 years for male and female, respectively. With respect to
36 212 income level; 69.4% and 80.9% of men and women, respectively either had no source of
37 213 income or earned less than 2000 rand. Table 1 provides the descriptive characteristics of the
38 214 participants.

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222 **Table 1 Demographic characteristics of the participants by sex**

Variables	Male (n=321) n(%)	Female (n=677) n(%)	Total (n=998) n(%)	p-value
Age group (years)				
18-25	40(12.5)	143(21.1)	183(18.3)	
26-35	74(23.1)	149(22.0)	223(22.3)	
36-45	67(20.9)	116(17.1)	183(18.3)	0.009
46-55	57(17.8)	110(16.2)	167(16.7)	
56-65	41(12.8)	99(14.6)	140(14.0)	
≥66	42(14.1)	60(8.9)	102(10.2)	
Level of education				
No formal schooling	62(19.3)	84(12.4)	146(14.6)	
Grade 1-7	57(17.8)	99(14.6)	156(15.6)	0.008
Grade 8-12	17(5.3)	409(60.4)	580(58.1)	
Tertiary	31(9.7)	85(12.6)	116(11.6)	
Monthly income (Rands)				
No income	134(41.7)	300(44.3)	445(44.6)	
R150-2000	89(27.7)	248(36.6)	326(32.7)	0.000
R2001-5000	74(23.1)	100(14.8)	174(17.4)	
R5001 and above	24(7.5)	29(4.3)	53(5.3)	
Marital status				
Single	193(60.3)	444(65.6)	637(63.9)	
Married	115(35.9)	185(27.3)	300(30.1)	
Separated	1(0.3)	5(0.7)	6(0.6)	0.002
Divorced	9(2.8)	13(1.9)	22(2.2)	
Widowed	2(0.6)	30(4.4)	32(3.2)	
Racial group				
Black	313(97.5)	666(98.4)	979(98.1)	
Coloured	8(2.8)	9(1.3)	17(1.7)	0.26
White	0(0.0)	2(0.3)	2(0.2)	
Type of employment				
Government employee	30(9.3)	33(4.9)	63(6.3)	
Non-government employment	98(30.5)	133(19.7)	231(23.2)	
Self-employment	30(9.3)	32(4.7)	62(6.2)	
Students	19(5.9)	80(11.8)	99(9.9)	0.00
Unemployed	115(24.2)	361(53.4)	476(47.7)	
Retired	29(9.0)	37(5.5)	66(6.6)	

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227 **Prevalence, Awareness and Treatment of Hypertension**

228 Of the 998 participants, 49.2% (n=491) were diagnosed of hypertension. Awareness of prior

229 diagnosis of hypertension was reported by 339 participants (69.1% of those hypertensive).

230 Among those aware of hypertension diagnosis, nearly all (91.7%, n=311) were on

231 hypertensive treatment. Treatment to target blood pressure occurred in 42.1% (n=131) among

232 the treated individuals.

233 **Factors associated with hypertension**

234 In bivariate analysis (Table 2), the following risk factors; aging, male sex, lower level of
 235 education (below grade 8), being married, unemployed, lower income level, never drank
 236 alcohol, sedentary lifestyle, both central and overall obesity were significantly associated
 237 with hypertension. Body mass index and age demonstrated positive linear association with
 238 prevalent hypertension.

239

240 **Table 2 Bivariate analysis showing the associated risk factors for hypertension**

Variables	Hypertensive	Normal BP	RR	95% CI	p-value
Sex					
Male	175(54.5)	146(45.5)	-	-	0.000
Female	316(46.7)	361(53.3)			
Age (years)					
≤25	35(19.1)	148(80.9)	-	-	0.000
26-35	66(29.6)	157(70.4)			
36-45	72(39.3)	111(60.7)			
46-55	133(67.7)	54(32.3)			
56-65	117(83.6)	23(16.4)			
≥66	88(86.3)	14(13.7)			
Level of education					
No formal schooling	77(52.7)	69(47.3)	0.4	0.3-0.5	0.000
Grade 1 to 7	118(75.6)	38(24.4)			
Grade 8 to 12	250(43.1)	330(56.9)			
Tertiary	46(39.7)	70(60.3)			
Marital status					
Never married	251(39.4)	386(60.6)	-	-	0.000
Married	211(64.3)	117(35.7)			
Employment					
Government employee	33(52.4)	30(47.6)	-	-	0.000
Non-government employee	104(45.0)	127(55.0)			
Self-employed	29(46.8)	33(53.2)			
Student	18(18.2)	81(81.8)			
Unemployed	252(52.9)	224(47.1)			
Retired	54(81.8)	12(18.2)			
Monthly income					
R2000	222(62.2)	135(37.8)	1.9	1.4-2.7	0.000
≥R2001	105(46.3)	122(53.7)			
Ever drink alcohol					
Yes	131(41.1)	188(58.9)	0.6	0.5-0.8	0.000
No	359(53.7)	310(46.3)			
Moderate intensity physical activity					
Yes	256(45.6)	305(54.4)	0.7	0.6-0.9	0.006
No	234(53.8)	201(46.2)			
Vigorous intensity physical activity					
Yes	58(37.9)	95(62.1)	0.6	0.4-0.8	0.002
No	433(51.5)	412(48.8)			
Body mass index (kg/m ²)					
Underweight	12(37.5)	20(62.5)	-	-	0.000
Normal	89(33.0)	181(67.0)			
Overweight	106(45.3)	128(54.7)			
Stage 1 obesity	114(55.6)	91(44.4)			
Stage 2 obesity	84(60.9)	54(39.1)			
Stage 3 obesity	76(72.4)	29(27.6)			
Central obesity derived from waist-to-hip ratio					
Yes	268(56.8)	204(43.2)	0.6	0.4-0.7	0.000
No	221(42.3)	301(57.7)			

WC derived central obesity

Obese	355(54.7)	294(45.3)	2.4	1.9-3.1	0.000
Not obese	135(38.9)	212(61.1)			

241 RR= Relative risk; CI= Confidence interval

242 In the multivariate logistic regression model analysis (Table 3), aging, being married, male
243 sex, concomitant diabetes mellitus, lower income level, being unemployed and central
244 obesity were the significant and independent determinants of prevalent hypertension.

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246 **Table 3 Multivariate logistic regression analysis showing the predictors of hypertension**

Variables	Beta	Wald	AOR (95% CI)	p-value
Age				
≤26 (Reference)				
Above 26	1.06	23.78	2.9(1.9-4.4)	0.005
Marital status				
Never married (Reference)				
Ever married	0.39	5.89	1.5(1.0-2.0)	0.015
Sex				
Female (Reference)				
Male	0.51	9.83	1.7(1.2-2.3)	0.000
Diabetes mellitus				
No (Reference)				
Yes	1.01	31.6	2.7(1.9-3.9)	0.000
Monthly income				
Middle-income >2000 (Reference)				
Low income ≤ 2000	0.49	9.48	1.6(1.2-2.2)	0.002
Employment				
Employed (Reference)				
Unemployed	0.33	4.01	1.4(1.0-1.9)	0.045
Central obesity derived from waist circumference				
No (Reference)				
Yes	0.63	10.0	2.1(1.5-2.8)	0.000

247 AOR=Adjusted odd ratios; CI= Confidence interval

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249 **Factors associated with hypertension awareness and control**

250 Hypertension unawareness occurred in 152 participants with significant difference by sex
251 (p=0.005). The following factors; male sex, lower ages, higher level of education, single
252 status, current employment status, higher income earners, current smokers, alcohol users,
253 non-diabetic and non-obese individuals were associated with hypertension unawareness in the
254 study (Table 4).

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Table 4 Bivariate analysis showing the associated factors of hypertension unawareness

Variables	Aware	Unaware	RR	95% CI	p-value
Sex					
Male	108(61.7)	67(38.3)	0.6	0.4-0.9	0.005
Female	232(73.4)	84(26.6)			
Age (years)					
<45	79(23.2)	95(54.6)	-	0.1-0.3	0.000
>45	261(82.3)	56(17.7)			
Level of education					
No formal schooling	57(73.1)	21(26.9)	-	-	0.002
Grade 1-7	93(78.8)	25(21.1)			
Grade 8-12	168(67.2)	82(32.8)			
Tertiary	22(48.9)	23(51.1)			
Marital status					
Never married	152(60.6)	99(39.4)			
Married	161(76.3)	50(23.7)	0.5	0.3-0.7	0.000
Employment status					
Employed	99(59.3)	68(40.7)	0.5	0.3-0.7	0.000
Unemployed	241(74.4)	83(25.6)			
Monthly income (Rands)					
<R2000	276(71.7)	109(28.3)	1.7	1.1-2.6	0.018
>R2000	64(60.4)	42(39.6)			
Current smokers					
Yes	33(50.0)	33(50.0)	0.4	0.2-0.7	0.000
No	307(72.2)	118(27.8)			
Ever drink alcohol					
Yes	67(50.8)	65(49.2)	0.3	0.2-0.5	0.000
No	272(76.2)	85(23.8)			
Diabetes mellitus					
Yes	114(85.1)	20(14.9)	0.3	0.2-0.5	0.000
No	226(63.3)	131(36.7)			
Obesity					
Yes	260(73.4)	94(26.6)	2.5	1.5-3.2	0.001
No	79(58.1)	57(41.9)			

RR= Relative risk; CI= Confidence interval

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275 **Table 5 Bivariate analysis showing the factors associated with hypertension control**

Variables	Controlled HTN	Uncontrolled HTN	RR	95% CI	p-value
Sex					
Male	34(35.4)	62(64.4)	0.8	0.5-1.3	0.262
Female	86(40.0)	129(60.0)			
Age (years)					
<45	31(47.7)	34(52.3)	1.6	0.9-2.8	0.061
>45	89(36.2)	157(63.8)			
Level of education					
No formal schooling	11(52.4)	10(47.6)	-	-	0.209
Grade 1-7	18(35.3)	33(64.7)			
Grade 8-12	56(35.4)	102(64.6)			
Tertiary	11(61.1)	7(38.6)			
Marital status					
Never married	56(42.4)	76(57.6)	1.5	1.0-2.4	0.072
Married	51(33.3)	102(66.7)			
Employment status					
Employed	36(41.4)	51(58.6)	1.2	0.7-2.0	0.0307
Unemployed	84(37.5)	40(62.5)			
Monthly income (Rands)					
<R2000	49(29.9)	115(70.1)	0.5	0.3-1.0	0.021
>R2000	27(45.8)	32(54.2)			
Current smokers					
Yes	11(39.3)	17(60.7)	1.0	0.5-2.3	0.544
No	109(38.5)	174(61.5)			
Ever drink alcohol					
Yes	18(32.7)	37(67.3)	0.7	0.4-1.3	0.204
No	102(39.8)	154(60.2)			
Diabetes mellitus					
Yes	87(56.9)	66(43.1)	0.7	0.4-1.1	0.052
No	105(66.5)	53(33.5)			
Obesity					
Yes	76(36.8)	125(62.2)	0.9	0.6-1.5	0.398
No	44(40.0)	66(60.0)			

276 RR= Relative risk; CI= Confidence interval; HTN= Hypertension

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278 **Discussion**

279 To the best knowledge of the authors, this is the first paper addressing the epidemiological
280 gaps on the prevalence, awareness, treatment and control of hypertension in the Buffalo City
281 Metropolitan Municipality (BCMM). We found a high prevalence of hypertension (49.2%) in
282 our study population. There seems to be an upward trend in the prevalence of hypertension in
283 the country which is rather unsurprising due to the rapid urbanization and its consequent
284 effect on population health. Our result is higher than Day et al.²³ study which reported 40%
285 prevalence of hypertension among South African adults in 2010. A lower prevalence of
286 hypertension (38.9%) was reported by Peer et al.²⁵ among black urban South Africans in
287 Cape Town. A nationally representative house-hold survey in South Africa reported a
288 prevalence range of 9% in Limpopo Province to 22.3% in Northern Cape Province.³⁴ Highest

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3 289 prevalence of hypertension (12.4%) was found among the black South African population.
4 Weimann et al.⁴⁰ estimated a higher prevalence of 37% and 52% in Eastern Cape and
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6 291 Northwest Provinces. The higher prevalence of 49.2% found among our sample is
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8 292 comparable to Northwest Province of 52%, but higher than that of Eastern Cape Province
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10 293 reported by Weimann et al.⁴⁰ Our result was obtained from the primary health care setting
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12 294 and thus, may have slightly overestimated the prevalence in the population.

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14 295 There is a wide variation in the prevalence of hypertension across the sub-Saharan Africa;
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16 296 from 23% among Zambian and Angola adults to 26% in adults in four selected sub-Saharan
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18 297 African countries.^{10-12,41} Akpan et al.⁹ reported prevalence of 48.3% among some rural
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20 298 dwelling adults in Eastern part of Nigeria, while 44.7% prevalence was documented among
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22 299 Ghanaian adults residing in a rural setting. Similar trend of increasing prevalence of
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24 300 hypertension have been reported worldwide; Chow et al.³⁰ found a prevalence of 40.8%
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26 301 among rural and urban dwellers in some selected high income countries (Canada, Sweden,
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28 302 United Arab Emirates), middle income countries (Argentina, Brazil, Chile, Poland, Turkey,
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30 303 Malaysia, South Africa, China, Colombia, Iran) and low income countries (Bangladesh,
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32 304 India, Pakistan and Zimbabwe). Higher prevalence was reported among some other
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34 305 developing countries with prevalence ranging from 50.7- 79.8% among adults living in urban
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36 306 areas of India, Latin America and China.^{42,43} Our finding further supports the epidemiological
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38 307 shift of non-communicable diseases to developing nations.^{13,44}

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42 309 Although a thorough comparison of various studies cannot be done as a result of differences
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44 310 in the definitions, methodology and populations used by various studies. However, the
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46 311 findings from this study indicate that South Africa is already at the fore front of the
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48 312 epidemiologic transition being complicated by advancement in technology attributed to
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50 313 urbanization and westernization. These are both the driving forces of the increasing burden of
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52 314 non-communicable disease risk factors of which hypertension is predominant. This is linked
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54 315 to adoption of unhealthy lifestyle behaviours and poor dietary practices as well as poor
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56 316 engagement in physical activity leading to obesity, and ultimately, cardiovascular risk factors
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58 317 like hypertension. Our findings signal a looming burden of non-communicable disease among
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60 318 the study participants if urgent actions are not taken.

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320 We found aging, male sex, being married, unemployment status, poverty, sedentary lifestyles,
321 obesity and diabetes mellitus as the important determinants of prevalent hypertension in the

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3 322 study population. Several other studies have also established a link between these risk factors.
4 323 Pires et al.¹² affirmed that increasing age, lower level of education and increasing weight
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6 324 were associated with hypertension. Additionally, Guwatudde et al.¹¹ found diabetes to be
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8 325 significantly associated with hypertension. Increasing age is often associated with changes in
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10 326 the body systems including the cardiovascular system such as the heart and arteries. Old
11 327 people suffer a great deal of cardiovascular risk factors, especially hypertension.⁴⁵
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14 329 We found higher prevalence of hypertension in individuals with lower level of education
15 330 (below grade 8). These individuals are most likely unemployed and earned less than R2000.
16 331 Although, the association between the level of education and health is rather complex; it can
17 332 be assumed that the more educated an individual is, the more knowledgeable he will be about
18 333 his health. Whether this assumption is true in our study population is rather speculative.
19 334 Cutler and Lleras-Muney⁴⁶ reported that education increases knowledge. Educated
20 335 individuals are more likely to be receptive to new developments including newly approved
21 336 drugs and often compliant with drug use.^{47,48} Our study participants with hypertension were
22 337 poor and unemployed. Their poor socio-economic status also limit their access to healthy
23 338 food and thus, increase consumption of readily available cheap foods which are contributing
24 339 to the burden of non-communicable risk factors such as obesity and hypertension. We found
25 340 higher prevalence of hypertension among men. Female hormonal effect is believed to be
26 341 protective⁴⁹ and since the majority of the women in this study were below 50 years, this could
27 342 be a plausible reason for our findings. Also, obesity, work stress, physical inactivity, alcohol
28 343 intake and salt intake have been reported to be high in men thus, resulting in higher odds of
29 344 developing hypertension.⁵⁰
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32 346 There is a substantial intersection between hypertension and diabetes because of the shared
33 347 metabolic pathway and risk factors.⁵¹⁻⁵³ Hypertension is always found in more than half of
34 348 individuals with type 2 diabetes and the chance of developing hypertension among persons
35 349 with type 2 diabetes is more than double.⁵⁴ Also, as shown by Murphy et al. and Bromfield
36 350 & Munter,^{55,56} there is a recognized link between hypertension, obesity, smoking, harmful use
37 351 of alcohol and physical inactivity and a larger percentage of hypertension burden is attributed
38 352 to these factors. The relationship between hypertension and obesity has long been established.
39 353 Obesity increases the chance of developing hypertension and increases the risk of developing
40 354 cardiovascular complications.^{57,58} As reported by Pandey et al.,⁵⁹ smoking increases the
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3 355 prevalence of hypertension.⁵³ Physical inactivity is a precursor to obesity and hypertension.
4 356 Physical inactivity is responsible for 20% of hypertension cases.⁶⁰
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8 358 This present study further illustrates that the majority (69.1%) of the hypertensive patients
9 359 were aware of their status, and of these, almost all (91.7%) were already on treatment with
10 360 only 38.6% achieving control. This awareness rate is higher than the 24% awareness rate
11 361 reported among South Asian adults.⁶¹ There is a wide variation of hypertension awareness
12 362 across African countries with rates ranging from between 8% in Nigeria to 81% among the
13 363 elderly individuals in Tunisia.⁶²
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20 365 Despite the scientific successes in anti-hypertensive drug discoveries, achieving treatment
21 366 targets remain a serious challenge. Although, nearly all of the participants with prior
22 367 diagnosis were already receiving treatment for hypertension which is a commendable effort,
23 368 however, only 38.6% achieved treatment targets. This is somewhat better than previous
24 369 studies conducted in Mthatha, South Africa and Zimbabwe, 25.5% and 32.8%,
25 370 respectively.^{22,31} It is also comparable to the rate of control of hypertension (36.4%) reported
26 371 by Day et al.²³ in a household survey conducted among South African adults in 2010.
27 372 Generally, hypertension control has been reported to be sub-optimal in Africa, ranging from
28 373 2.6% in Kenya to 42.2% in Ethiopia.⁶²⁻⁶⁴
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35 374 We observed that men, those earning more than R2000, age less than 45 years, employed,
36 375 cigarette smokers and alcohol users had higher rates of hypertension unawareness. Men have
37 376 been reported to have higher odds of developing hypertension and the high rate of
38 377 unawareness among them is not surprising. Females have been recognised to seek healthcare
39 378 better than men.⁶⁵ Traditional gender roles in Africa account for underutilisation of health
40 379 facilities among men; men are the breadwinners and are perceived as healthy.^{66,67} Hence, they
41 380 rarely seek health facilities for screening purposes unless when they are sick. Hypertension is
42 381 largely asymptomatic and as such, an affected individual will rarely seek healthcare. Our
43 382 findings have serious public health consequences; due to the clustering of cardiovascular
44 383 diseases among the individuals with hypertension unawareness. Younger individuals are
45 384 unlikely to visit health facilities without any major sickness. Hence, the high rate of
46 385 unawareness in those younger than 45 years. Beside, this cohort of individuals are pre-
47 386 occupied by their jobs. Older individuals tend to have multi-morbidity and as such, would
48 387 have had several opportunities to be screened for non-communicable diseases. Alcohol and
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3 388 nicotine dependence may explain our findings of high unawareness among alcohol users and
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5 389 current cigarette smokers, respectively.
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7 390 We found a high rate of uncontrolled hypertension (62.4%) in our study participants. Though,
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9 391 several factors have been implicated for the control of hypertension in Africa, which are
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11 392 generally related to the deficiencies in the healthcare system, non-adherence to medication
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13 393 regimen by the patients as well as the physicians' inertia to optimise treatment of
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15 394 hypertension.^{22,62} Several other studies also documented unavailability of anti-hypertensive
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17 395 drugs as well as non-adherence to clinic visits by the patients as a result of lack of
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19 396 transportation means and time.^{12,68,69} Poor treatment outcomes in Africa has been documented
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21 397 extensively.^{13,31,62,70,71} In comparison, higher levels of control (64.8% and 66%) of
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23 398 hypertension were reported in USA and Canada, respectively.^{72,73} This is not a surprise as
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25 399 management of hypertension is costly due to its chronic nature and developed countries have
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27 400 been recording successes in the reduction of the burden related to hypertension and other
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29 401 non-communicable diseases.⁷⁴

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31 402 Also, participants who had diabetes mellitus were found to have lower rate of controlled
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33 403 hypertension. Multi-morbidity with significant risks of poly-pharmacy are some of the
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35 404 reasons for the poor control of blood pressure in those with concomitant diabetes. Previous
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37 405 report from similar setting by Adeniyi et al.²² found poor control of blood pressure among
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39 406 individuals with concomitant diabetes. Poverty was associated with poor blood pressure
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41 407 control among our study participants already on treatment for hypertension. Poor treatment
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43 408 outcomes among individuals with poor earnings is not surprising. This can be linked to poor
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45 409 access despite the availability of medications at the health facility, some of our patients
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47 410 regularly miss appointments and fail to pick-up medications. Also, the patients are incapable
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49 411 to purchase essential drugs for hypertension (out of pocket) and as well as eat healthy foods
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51 412 that promote health, which are expensive and cannot be afforded by the low-income earning
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53 413 participants.⁷⁵

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56 57 415 **Strength and Limitations**

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59 416 The limitations of the study cannot be ignored. Firstly, this is a cross-sectional study hence,
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417 causality cannot be ascribed to the determinants. Our findings should be interpreted with
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419 418 caution in view of the convenience sampling of the participants at the primary health care
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420 419 facilities. We also did not obtain information on the hypertensive medications and as such,

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3 420 could not gain full understanding of the uncontrolled hypertension in our study participants.
4 421 Notwithstanding these limitations, the findings of the study provide useful epidemiological
5 422 data in view of the large sample size, largest out-patient clinics selected and the understudied
6 423 setting.
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10 424 **CONCLUSION**

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12 425 Findings of high prevalence and sub-optimal blood pressure control of hypertension requires
13 426 urgent attention of health authorities of Buffalo City Metropolitan Municipality. Also, the
14 427 clustering of cardiovascular risk factors in individuals with hypertension suggests that
15 428 integrated strategy addressing all the non-communicable diseases will be needed to mitigate
16 429 the scourge of the looming epidemic. Re-engineering of the primary health care in BCMM
17 430 will be crucial to dealing with the burden of non-communicable diseases in the region.
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23 431 *Consent for publication*

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25 432 All authors approved the submission of this final draft towards publication in a peer review
26 433 journal.
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29 435 *Availability of data and materials*

30 436 Data from this study will be made available on request.
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34 438 *Competing interests*

35 439 The authors declare no conflict of interest.
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46 446 *Authors' Contributions*

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48 447 EOO, DTG and OVA conceptualised, designed and drafted the paper. ES participated in data
49 448 collection and gave intellectual contribution into the manuscript. All authors read and
50 449 approved the final manuscript.
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FIGURE

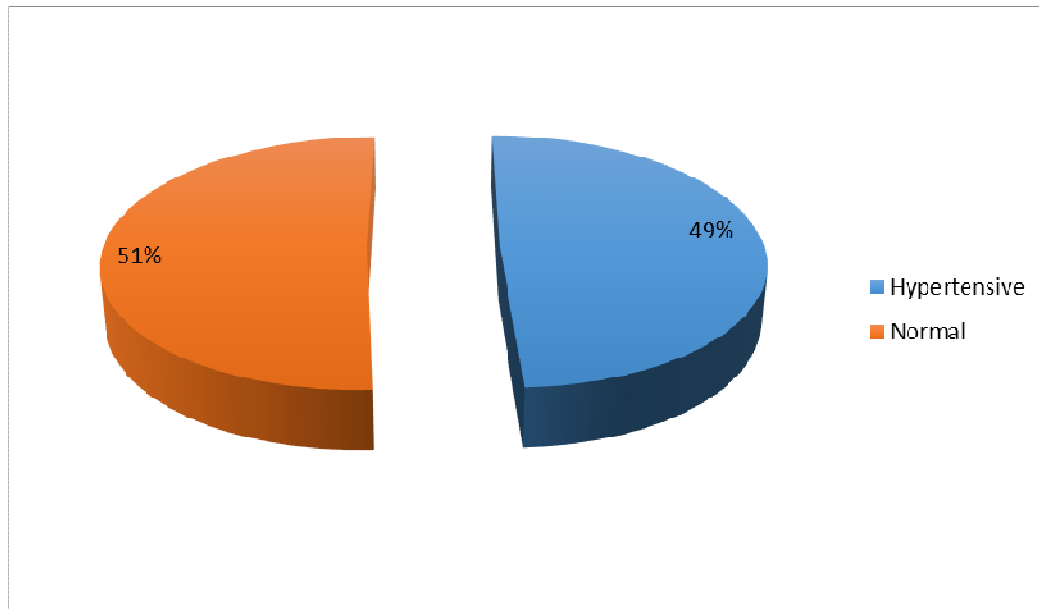


Figure 1 Prevalence of blood pressure

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract Pg 1 & 2	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction - Pg 3		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods – Pg 4		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

Results – Pg 7

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion – Pg 12

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information – Pg 17

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Social Epidemiology of Hypertension in Buffalo City Metropolitan Municipality (BCMM): Cross sectional Study of Determinants of Prevalence, Awareness, Treatment and Control among South African Adults

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Primary Subject Heading:	Epidemiology
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Keywords:	Hypertension < CARDIOLOGY, General diabetes < DIABETES & ENDOCRINOLOGY, Clinical governance < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PRIMARY CARE, PUBLIC HEALTH

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Manuscripts

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3 1 **Social Epidemiology of Hypertension in Buffalo City Metropolitan Municipality**
4 2 **(BCMM): Cross sectional Study of Determinants of Prevalence, Awareness, Treatment**
5 3 **and Control among South African Adults**

6
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52
53 33 **Keywords:** Blood Pressure Control, Diabetes mellitus, Hypertension, Obesity, South Africa

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55 34 **Word count:** 4,037

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57 35 5 tables and 1 figure

36 Abstract

37 **Objectives:** This study examined hypertension prevalence, awareness, treatment and control
38 and their determinants among adults attending health facilities in BCMM in the Eastern Cape.

39 **Design:** A cross-sectional analytical study.

40 **Settings:** The three largest out-patient clinics in BCMM.

41 **Participants:** Ambulatory adults (18 years and over) attending the study settings during the
42 study period (n=998).

43 **Primary outcome measure:** The prevalence of hypertension (systolic BP of ≥ 140 mmHg
44 and/or a diastolic BP of ≥ 90 mmHg or current medication for hypertension), the awareness of
45 it (prior diagnosis of it), and its treatment and control (Eighth Joint National Committee
46 Criteria of blood pressure $< 140/90$ mmHg).

47 **Secondary outcome measure:** Associated factors of hypertension, hypertension
48 unawareness and uncontrolled hypertension.

49 **Results:** Of the 998 participants included, the prevalence of hypertension was 49.2%.
50 Hypertension unawareness was reported by 152 participants (23.1%) with significant gender
51 difference ($p=0.005$). Male sex, age less than 45 years, higher level of education, single
52 status, current employment, higher monthly income, current smoking, alcohol usage, absence
53 of diabetes and non-obese were significantly associated ($p<0.05$) with hypertension
54 unawareness.

55 Of the participants who were aware of having hypertension (n=339), nearly all (91.7%,
56 n=311) were on anti-hypertensive medication and only 121 participants (38.9%) achieved the
57 blood pressure treatment target. In the multivariate logistic regression model analysis, ageing
58 (95%CI 1.9 to 4.4), being married (95%CI 1.0 to 2.0), male sex (95%CI 1.2 to 2.3),
59 concomitant diabetes (95%CI 1.9 to 3.9), lower monthly income (95%CI 1.2 to 2.2), being
60 unemployed (95%CI 1.0 to 1.9) and central obesity (95%CI 1.5 to 2.8) were the significant
61 and independent determinants of prevalent hypertension.

62 **Conclusion:** The prevalence and awareness of hypertension was high in the study population.
63 In addition, the sub-optimal control of blood pressure among treated individuals, as well as
64 the significant cardiovascular risk factors, warrant the attention of health authorities of
65 BCMM.

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68 Strengths and limitations of the study

- 69 • Large sample size of participants.
- 70 • First epidemiological data on hypertension prevalence, awareness,
71 treatment and control in BCMM.

- 72 • **Survey was conducted in BCMM's three largest out-patient clinics.**
- 73 • **Findings should be treated with caution in view of the cross-sectional**
- 74 **design and convenience sampling.**

76 Introduction

77 Cardiovascular diseases (CVD) are the leading cause of death (17.3 million deaths)
78 worldwide with a steep increase, especially in developing countries, and an 80% death toll
79 prevalence.¹ Cardiovascular diseases have been predicted to account for about 23.6 million
80 deaths by 2030.² Hypertension, one of the ten leading contributors to the global burden of
81 disease, is the most important modifiable risk factor for cardiovascular diseases and an
82 independent risk factor for mortality worldwide³⁻⁶ and has been described as a silent killer
83 due to its asymptomatic nature among the sufferers.⁷ About nine million people die from
84 hypertension annually.⁸

85 The prevalence of hypertension in Africa has been reported in several studies.⁹⁻¹²
86 Hypertension was once considered a disease of affluence, but is now prevalent among the
87 poor.¹³ In 2012, one in three adults were reported to be hypertensive, with the highest
88 prevalence recorded in Africa (50%).¹⁴ South Africa is facing a serious burden of
89 hypertension.¹⁵ More than 6.2 million South Africans are hypertensive; 3.2 million have a
90 blood pressure higher than 160/90mmHg and about 53 men and 78 women die daily from the
91 effects of hypertension.¹⁶ Considering the pace of economic growth in South Africa, a further
92 increase in the prevalence of hypertension is expected if drastic actions are not implemented
93 in the country.^{17,18} The treatment and control of hypertension are associated with a reduced
94 incidence of complications, such as stroke, coronary heart disease and kidney disease.¹⁹⁻²¹

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96 While the majority of individuals with hypertension remain undiagnosed, there is evidence
97 indicating sub-optimal control of blood pressure among individuals already in care for
98 hypertension in South Africa.²²⁻²⁵ Many reasons have been advanced for the sub-optimal
99 treatment outcomes, such as socio-economic and behavioural factors and health system
100 factors.^{22,26-28}

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102 In sub-Saharan Africa, the burden of hypertension is worsened by unreliable epidemiologic
103 data, under-diagnosis, poor treatment and uncontrolled hypertension.²⁹⁻³¹ Epidemiologic data

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3 104 helps to inform public health policies for the prevention and control of hypertension.³²
4 105 Likewise, prevention strategies, increased awareness, prompt detection, adequate treatment
5 106 and control of blood pressure are basic requirements for a comprehensive approach for the
6 107 reduction of hypertension, its complications and ultimately, its associated morbidity and
7 108 mortality.³³
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13 110 There is a paucity of data on the prevalence, awareness and control of hypertension in the
14 111 Eastern Cape, an understudied province in South Africa. Such a vital epidemiological data is
15 112 needed to inform policies on non-communicable diseases and resource distribution and for
16 113 the crafting of effective interventions. This study attempts to bridge the gap by determining
17 114 the prevalence and associated factors of hypertension, awareness and controlled hypertension
18 115 among adults attending the three largest out-patient clinics in the Buffalo City Municipality,
19 116 Eastern Cape, South Africa.
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26 118 **Methods**

27 119 **Study area and design**

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30 120 This study analyzed data from the Buffalo City Metropolitan Municipality (BCMM) Non-
31 121 Communicable Disease Surveillance study. We selected the three largest out-patient clinics
32 122 serving the residents of Buffalo City Municipality, South Africa. These clinics provide
33 123 primary health care services for the 755,200 residents of Buffalo City Municipality of Eastern
34 124 Cape Province.³⁴ All medical conditions except acute emergency cases present first at the
35 125 primary health care facilities prior to upward referrals to secondary health care facilities. The
36 126 family medicine outpatient clinic of Cecilia Makiwane Hospital and Nontyatyambo
37 127 Community Health Centre provide primary health care services to the predominantly black
38 128 South African residents of Mdantsane Township, a semi-urban community of Eastern Cape.
39 129 Empilweni-Gompo Community Health Centre was the third facility, situated in Duncan
40 130 Village, a suburban community of East London.
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50 131 **Participants and Sample size**

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52 132 The sample size of the Buffalo City Metropolitan Municipality (BCMM) Non-Communicable
53 133 Disease Surveillance study was based on the estimated proportion of individuals with
54 134 hypertension in the population. We estimated a sample size of 1107 participants across the
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3 135 three study sites (369 per site) based on the hypertension prevalence rate of 40% in South
4 136 Africa²³, allowing for a sampling error of 5% with a 95% confidence level.

7 137 All ambulatory individuals (patients and their family members) who fulfilled the inclusion
8 138 criteria and were attending the study settings during the period of study were recruited into
9 139 the study. All participants with abnormal findings agreed to be evaluated by the clinicians at
10 140 the study settings. This study was conducted in April-May, 2016. A convenience sampling
11 141 method was utilized.

12 142 **Eligibility criteria**

13 143 Participants were included if aged ≥ 18 years, attending the out-patient clinics of the selected
14 144 hospital and community health centres, were willing to participate and had fasted in the eight
15 145 hours prior to recruitment into the study. Exclusion criteria included the acutely ill,
16 146 psychotic, debilitated, pregnant or handicapped in any form such that obtaining
17 147 anthropometric measurement would be difficult. A consecutive sample of 1107 participants
18 148 took part in the study.

19 149 **Study instrument**

20 150 The participants were interviewed using the previously validated WHO STEPwise
21 151 questionnaire³⁵ which comprises three major items; demographic and behavioural data, and
22 152 measurements. The instrument was adapted locally and a pilot study, which included 20
23 153 participants at one of the sites, was conducted to validate its suitability to the local setting as
24 154 well as to test the effectiveness of the research process. However, the results of the pilot study
25 155 were not included in the main study.

26 156 **Ethical considerations**

27 157 Ethical approval was obtained in accordance with the Helsinki II Declaration from the
28 158 University of Fort Hare Research Ethics Committee and the Eastern Cape Department of
29 159 Health, reference number; GOO061SOLO01. The management of the sub-district department
30 160 of health as well as the head of the respective health facilities gave permission prior to data
31 161 collection. All participants provided written informed consent to participate in the study.
32 162 Anonymity and confidentiality were ensured.

33 163 **Data collection procedure**

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3 164 Data were obtained by personal interviews on demographic and behavioural characteristics
4 and measurements of blood pressure, blood glucose and anthropometric parameters.
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6 165 Demographic variables included sex, age, marital status, level of education, employment
7 status and average monthly income. Socioeconomic factors were measured by assessing the
8
9 166 average monthly income, level of education and employment status. Participants were
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11 167 categorised as low income earners if they earned R2000 or less per month and middle income
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13 168 earners if they earned R2000 to R5000 and high-income earners if they earned above R5000.
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15 169 Level of education was obtained by self-reporting of the highest grade level attained in
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17 170 school; levels were categorised as no formal education, primary (grade 1-7), secondary (grade
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19 171 8-12) or tertiary (post-secondary). Participants were defined as unemployed if they reported
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21 172 that they were not employed in either the formal or informal sectors.

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23 175 The following behavioural variables were obtained by self-reporting; cigarette smoking,
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25 176 alcohol use, physical activity, and fruit and vegetables consumption patterns. Participants
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27 177 were questioned on their servings of fruit and vegetables daily. The smoking categories were;
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29 178 primary smokers (smoking directly), secondary smokers (if living with a smoker) or non-
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31 179 smoker. Physical activity levels of participants were obtained by self-reporting and
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33 180 categorized based on their engagement in moderate (yes/no) or vigorous intensity (yes/no)
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35 181 exercise leading to an increase in heart rate and respiratory rate, such as gardening.

36 182 **Measurements**

37 183 Blood pressure (systolic and diastolic) was measured in accordance with standard protocols³⁶
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39 184 with a validated Microlife BP A100 Plus model. Hypertension was defined as an average of
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41 185 two systolic blood pressure of ≥ 140 mmHg and diastolic of ≥ 90 mmHg in accordance with
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43 186 the Eighth Joint National Committee (JNC 8) criteria. Participants who reported being
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45 187 informed of their hypertensive status by health professional(s) were considered aware.
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47 188 Uncontrolled hypertension among those on treatment with at least one or more anti-
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49 189 hypertensive medications was defined as systolic blood pressure greater than or equal to
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51 190 140mmHg and diastolic blood pressure greater than or equal to 90mmHg, in accordance with
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53 191 JNC 8 criteria. The fasting blood glucose of each participant was measured with a validated
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55 192 ACCU-CHEK glucose monitoring apparatus in fasting state. Participants were diagnosed
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57 193 with diabetes if their fasting blood glucose level was equal or greater than 7.0 mmol/L or if
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59 194 they were on current medications for diabetes. They were defined as pre-diabetic if the
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195 195 fasting blood glucose fell between 6.1-6.9 mmol/L.³⁷

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3 196 Body weight was measured in light clothes to the nearest 0.01kg in the standing position
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5 197 using a Soehnle Scale (Soenle-Waagen Gmbh Co., Muurhardt, Germany) and height was
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7 198 measured to the nearest 0.1m by a stadiometer in standing position with closed feet (without
8
9 199 shoes), holding their breath in full inspiration and Frankfurt line of vision.³⁸ Body mass index
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11 200 (BMI) was calculated as weight in kg divided by height in square metres (kg/m²). BMI was
12
13 201 categorized in accordance with WHO³⁹ as <18.5kg/m², 18.5-24.9kg/m², 25.5-29.9kg/m² and
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15 202 >30.0kg/m² as underweight, normal, overweight and obese, respectively.

16 203 **Statistical analysis**

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18 204 Data were expressed as mean values ± standard deviations (SD) for continuous variables.
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20 205 Counts (frequencies=n) and proportions (%) were reported for categorical variables. A
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22 206 bivariate analysis was used to examine variables that have a significant association with
23
24 207 hypertension and a p-value < 0.05 was considered statistically significant. The significant
25
26 208 variables were included in the binary logistic regression and were adjusted for confounding
27
28 209 factors. Analysis was carried out at a 95% confidence level. Statistical analysis was
29
30 210 performed with the Statistical Package for Social Science (SPSS) version 21 for windows
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32 211 (SPSS Inc., Chicago, IL, USA).

33 212 **Results**

34
35 213 Our analysis was based on 988 participants with complete data responses; 321 were males
36
37 214 and 677 were females (response rate, 92%). Eight percent of the participants were excluded
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39 215 from the study because of incomplete documentation of blood pressure, blood glucose,
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41 216 weight or height. More than half of the respondents – 56.5% of males and 60.2% of females
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43 217 – were between the ages of 18 and 45 years. With respect to income level, 69.4% of men and
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45 218 80.9% of women, either had no source of income or earned less than R2000 per month. Table
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47 219 1 provides the descriptive characteristics of the participants.

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227 **Table 1 Demographic characteristics of the participants by sex**

Variables	Male (n=321) n(%)	Female (n=677) n(%)	Total (n=998) n(%)	p-value
Age group (years)				
18-25	40(12.5)	143(21.1)	183(18.3)	
26-35	74(23.1)	149(22.0)	223(22.3)	
36-45	67(20.9)	116(17.1)	183(18.3)	0.009
46-55	57(17.8)	110(16.2)	167(16.7)	
56-65	41(12.8)	99(14.6)	140(14.0)	
≥66	42(14.1)	60(8.9)	102(10.2)	
Level of education				
No formal schooling	62(19.3)	84(12.4)	146(14.6)	
Grade 1-7	57(17.8)	99(14.6)	156(15.6)	0.008
Grade 8-12	171(53.3)	409(60.4)	580(58.1)	
Tertiary	31(9.7)	85(12.6)	116(11.6)	
Monthly income (Rands)				
No income	134(41.7)	300(44.3)	445(44.6)	
R150-2000	89(27.7)	248(36.6)	326(32.7)	0.000
R2001-5000	74(23.1)	100(14.8)	174(17.4)	
R5001 and above	24(7.5)	29(4.3)	53(5.3)	
Marital status				
Single	193(60.3)	444(65.6)	637(63.9)	
Married	115(35.9)	185(27.3)	300(30.1)	
Separated	1(0.3)	5(0.7)	6(0.6)	0.002
Divorced	9(2.8)	13(1.9)	22(2.2)	
Widowed	2(0.6)	30(4.4)	32(3.2)	
Racial group				
Black	313(97.5)	666(98.4)	979(98.1)	
Coloured	8(2.8)	9(1.3)	17(1.7)	0.026
White	0(0.0)	2(0.3)	2(0.2)	
Type of employment				
Government employee	30(9.3)	33(4.9)	63(6.3)	
Non-government employment	98(30.5)	133(19.7)	231(23.2)	
Self-employment	30(9.3)	32(4.7)	62(6.2)	
Students	19(5.9)	80(11.8)	99(9.9)	0.000
Unemployed	115(35.8)	361(53.4)	476(47.7)	
Retired	29(9.0)	37(5.5)	66(6.6)	

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231 **Prevalence, awareness and treatment of hypertension**

232 Of the 998 participants, 49.2% (n=491) were diagnosed with hypertension (Figure 1).

233 Awareness of prior diagnosis of hypertension was reported by 339 participants (69.1% of

234 total hypertensive individuals). Among those aware of having hypertension, nearly all

235 (91.7%, n=311) were on anti-hypertensive medication. Treatment to target blood pressure

236 occurred in 38.9% (n=121) of treated individuals.

237 **Factors associated with hypertension**

238 In bivariate analysis (Table 2), the following risk factors; ageing, male sex, lower level of

239 education (below grade 8), being married, unemployed, lower income level, never drank

240 alcohol, sedentary lifestyle and both central and overall obesity were significantly associated
 241 with hypertension. Body mass index and age demonstrated positive linear associations with
 242 prevalent hypertension.

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Table 2 Bivariate analysis showing the associated risk factors for hypertension

Variables	Hypertensive	Normal BP	RR	95% CI	p-value
Sex					
Male	175(54.5)	146(45.5)	1.4	1.0-1.8	0.012
Female	316(46.7)	361(53.3)			
Age (years)					
≤25	35(19.1)	148(80.9)	-	-	0.000
26-35	66(29.6)	157(70.4)			
36-45	72(39.3)	111(60.7)			
46-55	133(67.7)	54(32.3)			
56-65	117(83.6)	23(16.4)			
≥66	88(86.3)	14(13.7)			
Level of education					
No formal schooling	77(52.7)	69(47.3)			0.000
Grade 1 to 7	118(75.6)	38(24.4)			
Grade 8 to 12	250(43.1)	330(56.9)			
Tertiary	46(39.7)	70(60.3)			
Marital status					
Never married	251(39.4)	386(60.6)	0.4	0.3-0.5	0.000
Married	211(64.3)	117(35.7)			
Employment					
Government employee	33(52.4)	30(47.6)	-	-	0.000
Non-government employee	104(45.0)	127(55.0)			
Self-employed	29(46.8)	33(53.2)			
Student	18(18.2)	81(81.8)			
Unemployed	252(52.9)	224(47.1)			
Retired	54(81.8)	12(18.2)			
Monthly income					
R2000	222(62.2)	135(37.8)	1.9	1.4-2.7	0.000
≥R2001	105(46.3)	122(53.7)			
Ever drink alcohol					
Yes	131(41.1)	188(58.9)	0.6	0.5-0.8	0.000
No	359(53.7)	310(46.3)			
Moderate intensity physical activity					
Yes	256(45.6)	305(54.4)	0.7	0.6-0.9	0.006
No	234(53.8)	201(46.2)			
Vigorous intensity physical activity					
Yes	58(37.9)	95(62.1)	0.6	0.4-0.8	0.002
No	433(51.5)	412(48.8)			
Body mass index (kg/m ²)					
Underweight	12(37.5)	20(62.5)	-	-	0.000
Normal	89(33.0)	181(67.0)			
Overweight	106(45.3)	128(54.7)			
Stage 1 obesity	114(55.6)	91(44.4)			
Stage 2 obesity	84(60.9)	54(39.1)			
Stage 3 obesity	76(72.4)	29(27.6)			
Central obesity derived from waist-to-hip ratio					
Yes	268(56.8)	204(43.2)	0.6	0.4-0.7	0.000
No	221(42.3)	301(57.7)			
WC derived central obesity					
Obese	355(54.7)	294(45.3)	0.5	0.4-0.7	0.000
Not obese	135(38.9)	212(61.1)			

245 RR= Relative risk; CI= Confidence interval

246 In the multivariate logistic regression model analysis (Table 3), ageing, being married, male
 247 sex, concomitant diabetes mellitus, lower income level, being unemployed and central
 248 obesity were the significant and independent determinants of prevalent hypertension.

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Table 3 Multivariate logistic regression analysis showing the predictors of hypertension

Variables	Beta	Wald	AOR (95% CI)	p-value
Age				
≤26 (Reference)				
Above 26	1.06	23.78	2.9(1.9-4.4)	0.005
Marital status				
Never married (Reference)				
Ever married	0.39	5.89	1.5(1.0-2.0)	0.015
Sex				
Female (Reference)				
Male	0.51	9.83	1.7(1.2-2.3)	0.000
Diabetes mellitus				
No (Reference)				
Yes	1.01	31.6	2.7(1.9-3.9)	0.000
Monthly income				
Middle-income >2000 (Reference)				
Low income ≤ 2000	0.49	9.48	1.6(1.2-2.2)	0.002
Employment				
Employed (Reference)				
Unemployed	0.33	4.01	1.4(1.0-1.9)	0.045
Central obesity derived from waist circumference				
No (Reference)				
Yes	0.63	10.0	2.1(1.5-2.8)	0.000

251 AOR=Adjusted odd ratios; CI= Confidence interval

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253 **Factors associated with hypertension awareness and control**

254 Hypertension unawareness occurred in 152 participants with significant difference by sex
 255 (p=0.005). The following factors; male sex, lower age, higher level of education, single
 256 status, current employment status, higher income earners, current smokers, alcohol users,
 257 non-diabetic and non-obese individuals were associated with hypertension unawareness in the
 258 study (Table 4).

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266 **Table 4 Bivariate analysis showing the associated factors of hypertension awareness**

Variables	Aware	Unaware	RR	95% CI	p-value
Sex					
Male	108(61.7)	67(38.3)	0.6	0.4-0.9	0.005
Female	232(73.4)	84(26.6)			
Age (years)					
<45	79(23.2)	95(54.6)	0.5	0.1-0.3	0.000
>45	261(82.3)	56(17.7)			
Level of education					
No formal schooling	57(73.1)	21(26.9)	-	-	0.002
Grade 1-7	93(78.8)	25(21.1)			
Grade 8-12	168(67.2)	82(32.8)			
Tertiary	22(48.9)	23(51.1)			
Marital status					
Never married	152(60.6)	99(39.4)	0.5	0.3-0.7	0.000
Married	161(76.3)	50(23.7)			
Employment status					
Employed	99(59.3)	68(40.7)	0.5	0.3-0.7	0.000
Unemployed	241(74.4)	83(25.6)			
Monthly income (Rands)					
<R2000	276(71.7)	109(28.3)	1.7	1.1-2.6	0.018
>R2000	64(60.4)	42(39.6)			
Current smokers					
Yes	33(50.0)	33(50.0)	0.4	0.2-0.7	0.000
No	307(72.2)	118(27.8)			
Ever drink alcohol					
Yes	67(50.8)	65(49.2)	0.3	0.2-0.5	0.000
No	272(76.2)	85(23.8)			
Diabetes mellitus					
Yes	114(85.1)	20(14.9)			
No	226(63.3)	131(36.7)	0.3	0.2-0.5	0.000
Obesity					
Yes	260(73.4)	94(26.6)	2.5	1.5-3.2	0.001
No	79(58.1)	57(41.9)			

267 RR= Relative risk; CI= Confidence interval

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270 Among the participants on treatment for hypertension (n=311), only level of education (no
 271 formal schooling) was associated with uncontrolled hypertension. Concomitant diabetes
 272 mellitus was not significantly associated with uncontrolled hypertension (Table 5).

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279 **Table 5 Bivariate analysis showing the factors associated with hypertension control**

Variables	Controlled HTN	Uncontrolled HTN	RR	95% CI	p-value
Sex					
Male	34(35.4)	62(64.4)	0.8	0.5-1.3	0.262
Female	86(40.0)	129(60.0)			
Age (years)					
<45	31(47.7)	34(52.3)	1.6	0.9-2.8	0.061
>45	89(36.2)	157(63.8)			
Level of education					
No formal schooling	11(23.9)	35(76.1)	-	-	0.048
Grade 1-7	32(36.0)	57(64.0)			
Grade 8-12	68(43.0)	90(57.0)			
Tertiary	10(55.6)	8(44.4)			
Marital status					
Never married	56(42.4)	76(57.6)	0.8	0.5-1.2	0.165
Married	65(36.3)	114(63.7)			
Employment status					
Employed	36(41.4)	51(58.6)	0.9	0.5-1.4	0.344
Unemployed	85(38.1)	138(61.9)			
Monthly income (Rands)					
<R2000	98(38.9)	154(61.1)	1.0	0.6-1.8	0.551
>R2000	23(39.0)	36(61.0)			
Current smokers					
Yes	11(39.3)	17(60.7)	1.0	0.5-2.3	0.544
No	109(38.5)	174(61.5)			
Ever drink alcohol					
Yes	18(32.7)	37(67.3)	0.7	0.4-1.3	0.204
No	102(39.8)	154(60.2)			
Diabetes mellitus					
Yes	87(56.9)	66(43.1)	0.7	0.4-1.1	0.052
No	105(66.5)	53(33.5)			
Obesity					
Yes	76(36.8)	125(62.2)	0.9	0.6-1.5	0.398
No	44(40.0)	66(60.0)			

280 RR= Relative risk; CI= Confidence interval; HTN= Hypertension

281

282 **Discussion**

283 To the best knowledge of the authors, this is the first paper addressing epidemiological gaps
284 regarding the prevalence, awareness, treatment and control of hypertension in the Buffalo
285 City Metropolitan Municipality (BCMM). We found a high prevalence of hypertension
286 (49.2%) in our study population. There seems to be an upward trend in the prevalence of
287 hypertension in the country which is rather unsurprising, given rapid urbanization and its
288 consequent effects on population health. Our result is higher than that in Day et al.'s²³ study,
289 which reported a 40% prevalence of hypertension among South African adults in 2010. A
290 lower prevalence of hypertension (38.9%) was reported by Peer et al.²⁵ among black urban
291 South African adults between the ages of 24 and 65 years in Cape Town. A nationally
292 representative house-hold survey in South Africa which included individuals aged 15 years
293 and above reported a prevalence range of 9% in Limpopo Province to 22.3% in Northern

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3 294 Cape Province.³⁴ The highest prevalence of hypertension (12.4%) was found among the black
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5 295 South African population. Weimann et al.⁴⁰ estimated a higher prevalence, at 37% and 52%,
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7 296 in the Eastern Cape and Northwest Provinces. The higher prevalence of 49.2% found among
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9 297 our sample is comparable to Northwest Province's 52%, but higher than the percentage
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11 298 reported for the Eastern Cape Province by Weimann et al.⁴⁰ with an almost similar age
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13 299 distribution. Our result was obtained from the primary health care setting and thus, may have
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15 300 slightly overestimated the prevalence in the population. However, considering the age
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17 301 distribution of the study participants, with more than half below the of age 45, such a high
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19 302 prevalence of hypertension further signifies the need for urgent interventions as population
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21 303 ageing is often associated with a higher prevalence of hypertension

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23 304 There is a wide variation in the prevalence of hypertension across sub-Saharan Africa; from
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25 305 23% among Zambian and Angolan adults to 26% in adults in four selected sub-Saharan
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27 306 African countries.^{10-12,41} Akpan et al.⁹ reported a prevalence of 48.3% among rural adults in
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29 307 the eastern part of Nigeria, while a 44.7% prevalence was documented among rural Ghanaian
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31 308 adults. Similar trends of increasing hypertension prevalence have been reported worldwide;
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33 309 Chow et al.³⁰ found a prevalence of 40.8% among rural and urban dwellers in selected high-
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35 310 income countries (Canada, Sweden, United Arab Emirates), middle-income countries
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37 311 (Argentina, Brazil, Chile, Poland, Turkey, Malaysia, South Africa, China, Colombia and
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39 312 Iran) and low-income countries (Bangladesh, India, Pakistan and Zimbabwe). A higher
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41 313 prevalence was reported in certain other developing countries, with prevalence ranging from
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43 314 50.7% to 79.8% among adults living in urban areas of India, Latin America and China.^{42,43}
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45 315 Our finding further supports the epidemiological shift of non-communicable diseases to
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47 316 developing nations.^{13,44}

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51 318 Although a thorough comparison of various studies cannot be done as a result of differences
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53 319 in the definitions, methodology and populations used, the findings from this study indicate
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55 320 that South Africa is already at the forefront of the epidemiologic transition. The shift is being
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57 321 exacerbated by advancements in technology attributed to urbanization and westernization.
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59 322 These are both the driving forces of the increasing burden of non-communicable disease risk
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323 factors of which hypertension is predominant. It is linked to the adoption of unhealthy
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325 lifestyle behaviours, poor dietary practices and poor engagement in physical activity, leading
to obesity, and ultimately, cardiovascular risk factors like hypertension. Our findings signal a

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3 326 looming burden of non-communicable disease among the study participants if urgent actions
4 327 are not taken.

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8 329 We found ageing, male sex, being married, unemployment status, poverty, sedentary
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10 330 lifestyles, obesity and diabetes mellitus as the important determinants of prevalent
11 331 hypertension in the study population. Several other studies have also established a link
12 332 between these risk factors. Pires et al.¹² affirmed that increasing age, lower level of education
13 333 and increasing weight were associated with hypertension. Additionally, Guwatudde et al.¹¹
14 334 found diabetes to be significantly associated with hypertension. Increasing age is often
15 335 associated with changes in the body systems, including the cardiovascular system such as the
16 336 heart and arteries. Old people suffer a great deal of cardiovascular risk factors, especially
17 337 hypertension.⁴⁵

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24 339 We found a higher prevalence of hypertension in individuals with a lower level of education
25 340 (below grade 8). These individuals are most likely to be unemployed and to earn less than
26 341 R2000 per month. The association between level of education and health is rather complex; it
27 342 can be assumed that the more educated an individual is, the more knowledgeable he will be
28 343 on matters of health. Whether this assumption is true in our study population is rather
29 344 speculative. Cutler and Lleras-Muney⁴⁶ reported that education increases knowledge.
30 345 Educated individuals are more likely to be receptive to new developments, including newly
31 346 approved drugs, and are often compliant with drug use.^{47,48} Our study participants with
32 347 hypertension were poor and unemployed. Their socio-economic status limited their access to
33 348 healthy foods and increased their consumption of readily available, cheap foods which
34 349 contribute to risk factors such as obesity and hypertension. This should, however, be
35 350 interpreted with caution, as being unemployed does not necessarily denote a low income.
36 351 Underlying factors associated with unemployment, such as psychological stress, could
37 352 contribute to the high prevalence of hypertension among this cohort. We found a higher
38 353 prevalence of hypertension among men. Female hormonal effect is believed to be protective⁴⁹
39 354 and since the majority of the women in this study were below the age of 50, this could be a
40 355 plausible reason for our findings. Also, obesity, work stress, physical inactivity, alcohol
41 356 intake and salt intake have been reported to be high in men, resulting in higher odds of men
42 357 developing hypertension.⁵⁰

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3 359 There is a substantial intersection between hypertension and diabetes because of the shared
4 360 metabolic pathway and risk factors.⁵¹⁻⁵³ Hypertension is always found in more than half of
5 361 individuals with type-2 diabetes and the chances of developing hypertension among persons
6 362 with type-2 diabetes is more than double than that amongst non-diabetic persons.⁵⁴ Also, as
7 363 shown by Murphy et al. and Bromfield & Munter,^{55,56} there is a recognized link between
8 364 hypertension, obesity, smoking, harmful use of alcohol and physical inactivity and a large
9 365 percentage of the hypertension burden is attributed to these factors. The relationship between
10 366 hypertension and obesity has long been established. Obesity increases the chance of
11 367 developing hypertension and increases the risk of developing cardiovascular
12 368 complications.^{57,58} As reported by Pandey et al,⁵⁹ smoking increases the prevalence of
13 369 hypertension.⁵³ Physical inactivity is a precursor to obesity and hypertension. Physical
14 370 inactivity is responsible for 20% of hypertension cases.⁶⁰

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16 372 The present study further illustrates that the majority (69.1%) of the hypertensive patients
17 373 were aware of their status, and of these, almost all (91.7%) were already on treatment with
18 374 only 38.9% achieving control. This awareness rate is higher than the 24% awareness rate
19 375 reported among South Asian adults.⁶¹ There is a wide variation of hypertension awareness
20 376 across African countries with rates ranging from 8% in Nigeria to 81% among elderly
21 377 individuals in Tunisia.⁶² Also, the study settings being health facilities might have contributed
22 378 to the high awareness prevalence recorded in this study.

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24 380 Despite scientific successes in anti-hypertensive drug discoveries, achieving treatment targets
25 381 remains a serious challenge. Although nearly all of the participants with prior diagnosis were
26 382 already receiving treatment for hypertension, a commendable effort, only 38.9% achieved
27 383 treatment targets. This is somewhat better than previous studies conducted in Mthatha, South
28 384 Africa (25.5%) and Zimbabwe, (32.8%).^{22,31} It is also comparable to the rate of control of
29 385 hypertension (36.4%) reported by Day et al.²³ in a household survey conducted among South
30 386 African adults in 2010. Generally, hypertension control has been reported to be sub-optimal
31 387 in Africa, ranging from 2.6% in Kenya to 42.2% in Ethiopia.⁶²⁻⁶⁴

32 388 We observed that men, those earning more than R2000 per month, those aged under 45 years,
33 389 employed, cigarette smokers and alcohol users had higher rates of hypertension unawareness.
34 390 Men have been reported to have higher odds of developing hypertension and the high rate of
35 391 unawareness among them is not surprising. Females have been recognized as more likely to

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3 392 seek healthcare than men.⁶⁵ Traditional gender roles in Africa account for the under-
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5 393 utilization of health facilities among men; men are the breadwinners and are perceived as
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7 394 healthy.^{66,67} Hence, they rarely seek health facilities for screening purposes unless they are
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9 395 sick. Hypertension is largely asymptomatic and this being the case, an affected individual
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11 396 will rarely seek healthcare. Our findings have serious public health consequences, due to the
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13 397 clustering of cardiovascular diseases among the individuals with hypertension unawareness.
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15 398 Younger individuals are unlikely to visit health facilities without any major sickness. Hence
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17 399 the high rate of unawareness in those younger than 45 years. Besides, this cohort of
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19 400 individuals are pre-occupied by their jobs. Older individuals tend to have multi-morbidity and
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21 401 as such, would have had several opportunities to be screened for non-communicable diseases.
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23 402 Alcohol-and nicotine-dependence may explain our findings of high unawareness among
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25 403 alcohol users and current cigarette smokers, respectively.

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27 404 We found a high rate of uncontrolled hypertension (62.4%) in our study participants. Several
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29 405 factors have been implicated for the poor control of hypertension in Africa, which are
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31 406 generally related to deficiencies in the healthcare system, non-adherence to medication
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33 407 regimens by patients and physicians' inertia to optimize treatment of hypertension.^{22,62}
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35 408 Several studies have documented the unavailability of anti-hypertensive drugs as well as non-
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37 409 adherence to clinic visits by patients as a result of lack of transportation and time.^{12,68,69} Poor
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39 410 treatment outcomes in Africa has been documented extensively.^{13,31,62,70,71} In comparison,
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41 411 higher levels of control (64.8% and 66%) of hypertension were reported in the USA and
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43 412 Canada, respectively.^{72,73} This is not a surprise as the management of hypertension is costly
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45 413 due to its chronic nature. Developed countries have been recording successes in the reduction
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47 414 of the burden related to hypertension and other non-communicable diseases.⁷⁴

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49 415 Also, participants who had diabetes mellitus were found to have a lower rate of controlled
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51 416 hypertension. Multi-morbidity with significant risks of poly-pharmacy are some of the
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53 417 reasons for the poor control of blood pressure in those with concomitant diabetes. A study in
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55 418 a similar setting by Adeniyi et al.²² found poor control of blood pressure among individuals
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57 419 with concomitant diabetes. Illiteracy was associated with poor blood pressure control among
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59 420 our study participants already on treatment for hypertension. Poor treatment outcomes among
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61 421 individuals with no formal education is not surprising. Despite the availability of medications
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63 422 at the health facility, some of our patients regularly miss appointments and fail to collect
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65 423 medications. Education is said to be "power" and Cutler and Lleras-Muney⁴⁶ assert that
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67 424 education increases knowledge. There is a possibility of a lack of adequate knowledge on the

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3 425 importance of medication use in the control of hypertension among illiterate persons. In
4 426 addition, the benefits of positive lifestyle behaviours for the control of hypertension might not
5 427 be fully appreciated by such individuals. Likewise, lack of education generally leads to
6 428 poverty; thus poorly educated patients are less likely to be able to purchase essential drugs for
7 429 hypertension or to eat as healthily, as healthy foods tend to cost far more low-cost,
8 430 carbohydrate-rich foods.⁷⁵
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14 432 **Strengths and limitations**

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17 433 The limitations of the study cannot be ignored. Firstly, this was a cross-sectional study, hence
18 434 causality cannot be ascribed to the determinants. Our findings should be interpreted with
19 435 caution in view of the convenience sampling of the participants at primary health care
20 436 facilities. We also did not obtain information on the hypertensive medications being used and
21 437 therefore could not gain a full understanding of the uncontrolled hypertension in our study
22 438 participants. Notwithstanding these limitations, the findings of the study provide useful
23 439 epidemiological data in view of the large sample size, the large out-patient clinics selected
24 440 and the previously understudied setting.
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32 441 **CONCLUSION**

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34 442 The findings of a high prevalence of hypertension and sub-optimal blood pressure control of
35 443 hypertension requires the urgent attention of health authorities in Buffalo City Metropolitan
36 444 Municipality. Also, the clustering of cardiovascular risk factors in individuals with
37 445 hypertension suggests that an integrated strategy addressing all the non-communicable
38 446 diseases will be needed to mitigate the looming epidemic. Strategies aimed at the prevention
39 447 of hypertension, its early diagnosis and treatment to target blood pressure levels are needed in
40 448 BCMM. Also, the re-engineering of the primary health care system will be crucial towards
41 449 dealing with the burden of non-communicable diseases in the region.
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49 450 ***Consent for publication***

50 451 All authors approved the submission of this final draft towards publication in a peer reviewed
51 452 journal.
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55 454 ***Availability of data and materials***

56 455 Data from this study will be made available on request.
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3 4564 457 **Competing interests**

5 458 The authors declare no conflict of interest.

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16 46417 465 **Authors' contributions**18 466 EOO, DTG and OVA conceptualised, designed and drafted the paper. ES participated in data
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21 467
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20 681 **Figure 1. Prevalence of Hypertension**
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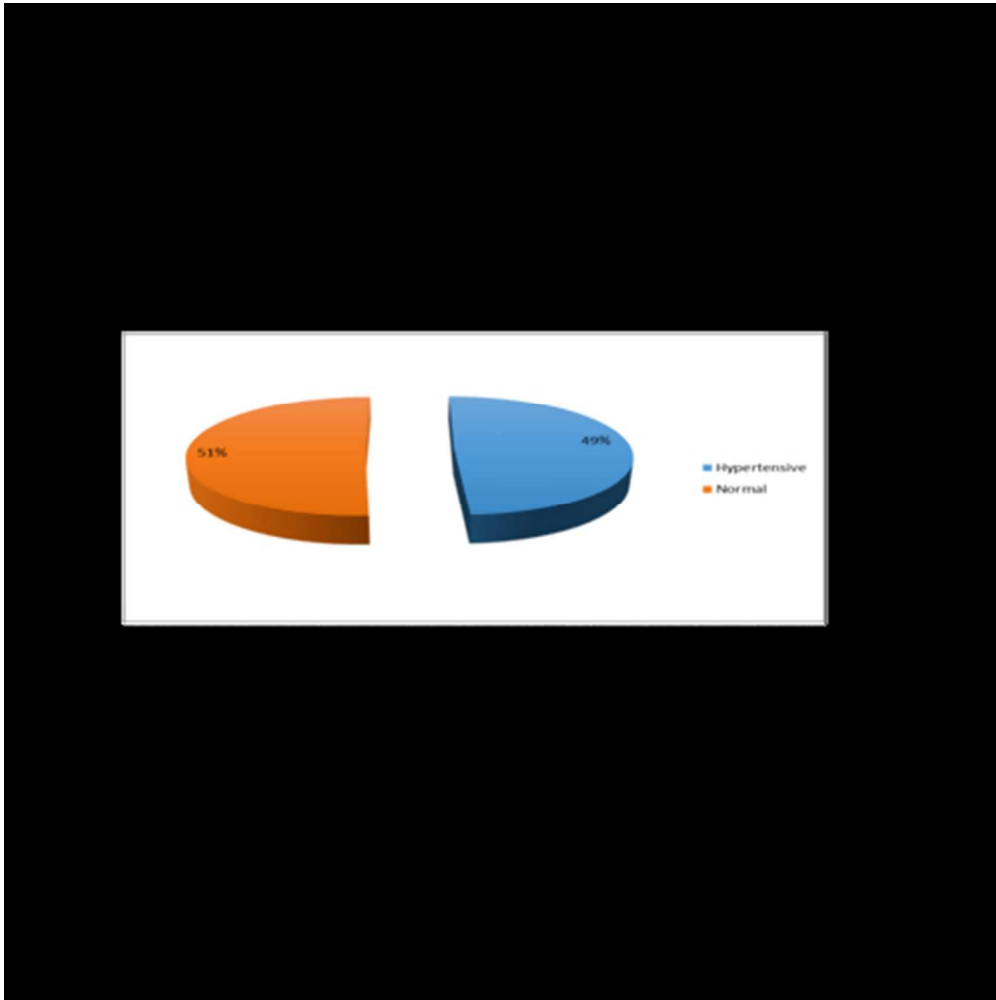


Figure 1. Prevalence of Hypertension

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract. – Page 1 (b) Provide in the abstract an informative and balanced summary of what was done and what was found – Page 2
Introduction		
Background/rationale- pg	2	Explain the scientific background and rationale for the investigation being reported – page 3 to 4
Objectives	3	State specific objectives, including any pre-specified hypotheses – Page 4
Methods		
Study design	4	Present key elements of study design early in the paper – Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection – Page 4 to 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants – Page 4 to 5 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – Page 6 to 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group – Page 6 to 7
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at – Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why – Page 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding – Page 7 (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy – Page 7 (e) Describe any sensitivity analyses

Continued on next page

Results – Pg 7

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders – Page 7 to 8 (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included – Page 8 to 12. (b) Report category boundaries when continuous variables were categorized. Page 8 to 12 (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives – Page 12 to 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias – Page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence – Page 17
Generalisability	21	Discuss the generalisability (external validity) of the study results – Page 17

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based – Page 18
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Social Epidemiology of Hypertension in Buffalo City Metropolitan Municipality (BCMM): Cross sectional Study of Determinants of Prevalence, Awareness, Treatment and Control among South African Adults

Journal:	<i>BMJ Open</i>
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, General practice / Family practice, Global health, Public health, Patient-centred medicine
Keywords:	Hypertension < CARDIOLOGY, General diabetes < DIABETES & ENDOCRINOLOGY, Clinical governance < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PRIMARY CARE, PUBLIC HEALTH

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Manuscripts

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3 1 **Social Epidemiology of Hypertension in Buffalo City Metropolitan Municipality**
4 2 **(BCMM): Cross sectional Study of Determinants of Prevalence, Awareness, Treatment**
5 3 **and Control among South African Adults**

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53 33 **Keywords:** Blood Pressure Control, Diabetes mellitus, Hypertension, Obesity, South Africa

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55 34 **Word count:** 4,037

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57 35 5 tables and 1 figure

36 Abstract

37 **Objectives:** This study examined hypertension prevalence, awareness, treatment and control
38 and their determinants among adults attending health facilities in BCMM in the Eastern Cape.

39 **Design:** A cross-sectional analytical study.

40 **Settings:** The three largest out-patient clinics in BCMM.

41 **Participants:** Ambulatory adults (18 years and over) attending the study settings during the
42 study period (n=998).

43 **Primary outcome measure:** The prevalence of hypertension (systolic BP of ≥ 140 mmHg
44 and/or a diastolic BP of ≥ 90 mmHg or current medication for hypertension), the awareness of
45 it (prior diagnosis of it), and its treatment and control (Eighth Joint National Committee
46 Criteria of blood pressure $< 140/90$ mmHg).

47 **Secondary outcome measure:** Associated factors of hypertension, hypertension
48 unawareness and uncontrolled hypertension.

49 **Results:** Of the 998 participants included, the prevalence of hypertension was 49.2%.
50 Hypertension unawareness was reported by 152 participants (23.1%) with significant gender
51 difference ($p=0.005$). Male sex, age less than 45 years, higher level of education, single
52 status, current employment, higher monthly income, current smoking, alcohol usage, absence
53 of diabetes and non-obese were significantly associated ($p<0.05$) with hypertension
54 unawareness.

55 Of the participants who were aware of having hypertension (n=339), nearly all (91.7%,
56 n=311) were on anti-hypertensive medication and only 121 participants (38.9%) achieved the
57 blood pressure treatment target. In the multivariate logistic regression model analysis, ageing
58 (95%CI 1.9 to 4.4), being married (95%CI 1.0 to 2.0), male sex (95%CI 1.2 to 2.3),
59 concomitant diabetes (95%CI 1.9 to 3.9), lower monthly income (95%CI 1.2 to 2.2), being
60 unemployed (95%CI 1.0 to 1.9) and central obesity (95%CI 1.5 to 2.8) were the significant
61 and independent determinants of prevalent hypertension.

62 **Conclusion:** The prevalence and awareness of hypertension was high in the study population.
63 In addition, the sub-optimal control of blood pressure among treated individuals, as well as
64 the significant cardiovascular risk factors, warrant the attention of health authorities of
65 BCMM and the country.

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68 Strengths and limitations of the study

- 69 • Large sample size of participants.
- 70 • First epidemiological data on hypertension prevalence, awareness,
71 treatment and control in BCMM.

- Survey was conducted in BCMM's three largest out-patient clinics.
- Findings should be treated with caution in view of the cross-sectional design and convenience sampling.

Introduction

Cardiovascular diseases (CVD) are the leading cause of death (17.3 million deaths) worldwide with a steep increase, especially in developing countries, and an 80% death toll prevalence.¹ Cardiovascular diseases have been predicted to account for about 23.6 million deaths by 2030.² Hypertension, one of the ten leading contributors to the global burden of disease, is the most important modifiable risk factor for cardiovascular diseases and an independent risk factor for mortality worldwide³⁻⁶ and has been described as a silent killer due to its asymptomatic nature among the sufferers.⁷ About nine million people die from hypertension annually.⁸

The prevalence of hypertension in Africa has been reported in several studies.⁹⁻¹² Hypertension was once considered a disease of affluence, but is now prevalent among the poor.¹³ In 2012, one in three adults were reported to be hypertensive, with the highest prevalence recorded in Africa (50%).¹⁴ South Africa is facing a serious burden of hypertension.¹⁵ More than 6.2 million South Africans are hypertensive; 3.2 million have a blood pressure higher than 160/90mmHg and about 53 men and 78 women die daily from the effects of hypertension.¹⁶ Considering the pace of economic growth in South Africa, a further increase in the prevalence of hypertension is expected if drastic actions are not implemented in the country.^{17,18} The treatment and control of hypertension are associated with a reduced incidence of complications, such as stroke, coronary heart disease and kidney disease.¹⁹⁻²¹

While the majority of individuals with hypertension remain undiagnosed, there is evidence indicating sub-optimal control of blood pressure among individuals already in care for hypertension in South Africa.²²⁻²⁵ Many reasons have been advanced for the sub-optimal treatment outcomes, such as socio-economic and behavioural factors and health system factors.^{22,26-28}

In sub-Saharan Africa, the burden of hypertension is worsened by unreliable epidemiologic data, under-diagnosis, poor treatment and uncontrolled hypertension.²⁹⁻³¹ Epidemiologic data

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3 104 helps to inform public health policies for the prevention and control of hypertension.³²
4 105 Likewise, prevention strategies, increased awareness, prompt detection, adequate treatment
5 106 and control of blood pressure are basic requirements for a comprehensive approach for the
6 107 reduction of hypertension, its complications and ultimately, its associated morbidity and
7 108 mortality.³³
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12 110 There is a paucity of data on the prevalence, awareness and control of hypertension in the
13 111 Eastern Cape, an understudied province in South Africa. Such a vital epidemiological data is
14 112 needed to inform policies on non-communicable diseases and resource distribution and for
15 113 the crafting of effective interventions. This study attempts to bridge the gap by determining
16 114 the prevalence and associated factors of hypertension, awareness and controlled hypertension
17 115 among adults attending the three largest out-patient clinics in the Buffalo City Municipality,
18 116 Eastern Cape, South Africa.
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26 118 **Methods**

27 119 **Study area and design**

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30 120 This study analyzed data from the Buffalo City Metropolitan Municipality (BCMM) Non-
31 121 Communicable Disease Surveillance study. We selected the three largest out-patient clinics
32 122 serving the residents of Buffalo City Municipality, South Africa. These clinics provide
33 123 primary health care services for the 755,200 residents of Buffalo City Municipality of Eastern
34 124 Cape Province.³⁴ All medical conditions except acute emergency cases present first at the
35 125 primary health care facilities prior to upward referrals to secondary health care facilities. The
36 126 family medicine outpatient clinic of Cecilia Makiwane Hospital and Nontyatyambo
37 127 Community Health Centre provide primary health care services to the predominantly black
38 128 South African residents of Mdantsane Township, a semi-urban community of Eastern Cape.
39 129 Empilweni-Gompo Community Health Centre was the third facility, situated in Duncan
40 130 Village, a suburban community of East London.
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51 131 **Participants and Sample size**

52 132 The sample size of the Buffalo City Metropolitan Municipality (BCMM) Non-Communicable
53 133 Disease Surveillance study was based on the estimated proportion of individuals with
54 134 hypertension in the population. We estimated a sample size of 1107 participants across the
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3 135 three study sites (369 per site) based on the hypertension prevalence rate of 40% in South
4 136 Africa²³, allowing for a sampling error of 5% with a 95% confidence level.

7 137 All ambulatory individuals (patients and their family members) who fulfilled the inclusion
8 138 criteria and were attending the study settings during the period of study were recruited into
9 139 the study. All participants with abnormal findings agreed to be evaluated by the clinicians at
10 140 the study settings. This study was conducted in April-May, 2016. A convenience sampling
11 141 method was utilized.

12 142 **Eligibility criteria**

13 143 Participants were included if aged ≥ 18 years, attending the out-patient clinics of the selected
14 144 hospital and community health centres, were willing to participate and had fasted in the eight
15 145 hours prior to recruitment into the study. Exclusion criteria included the acutely ill, psychotic,
16 146 debilitated, pregnant or handicapped in any form such that obtaining anthropometric
17 147 measurement would be difficult. A consecutive sample of 1107 participants took part in the
18 148 study.

19 149 **Study instrument**

20 150 The participants were interviewed using the previously validated WHO STEPwise
21 151 questionnaire³⁵ which comprises three major items; demographic and behavioural data, and
22 152 measurements. The instrument was adapted locally and a pilot study, which included 20
23 153 participants at one of the sites, was conducted to validate its suitability to the local setting as
24 154 well as to test the effectiveness of the research process. However, the results of the pilot study
25 155 were not included in the main study.

26 156 **Ethical considerations**

27 157 Ethical approval was obtained in accordance with the Helsinki II Declaration from the
28 158 University of Fort Hare Research Ethics Committee and the Eastern Cape Department of
29 159 Health, reference number; GOO061SOLO01. The management of the sub-district department
30 160 of health as well as the head of the respective health facilities gave permission prior to data
31 161 collection. All participants provided written informed consent to participate in the study.
32 162 Anonymity and confidentiality were ensured.

33 163 **Data collection procedure**

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3 164 Data were obtained by personal interviews on demographic and behavioural characteristics
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5 165 and measurements of blood pressure, blood glucose and anthropometric parameters.
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7 166 Demographic variables included sex, age, marital status, level of education, employment
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9 167 status and average monthly income. Socioeconomic factors were measured by assessing the
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11 168 average monthly income, level of education and employment status. Participants were
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13 169 categorised as low income earners if they earned R2000 or less per month and middle income
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15 170 earners if they earned R2000 to R5000 and high-income earners if they earned above R5000.
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17 171 Level of education was obtained by self-reporting of the highest grade level attained in
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19 172 school; levels were categorised as no formal education, primary (grade 1-7), secondary (grade
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21 173 8-12) or tertiary (post-secondary). Participants were defined as unemployed if they reported
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23 174 that they were not employed in either the formal or informal sectors.

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25 175 The following behavioural variables were obtained by self-reporting; cigarette smoking,
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27 176 alcohol use, physical activity, and fruit and vegetables consumption patterns. Participants
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29 177 were questioned on their servings of fruit and vegetables daily. The smoking categories were;
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31 178 primary smokers (smoking directly), secondary smokers (if living with a smoker) or non-
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33 179 smoker. Physical activity levels of participants were obtained by self-reporting and
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35 180 categorized based on their engagement in moderate (yes/no) or vigorous intensity (yes/no)
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37 181 exercise leading to an increase in heart rate and respiratory rate, such as gardening.

38 182 **Measurements**

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40 183 Blood pressure (systolic and diastolic) was measured in accordance with standard protocols³⁶
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42 184 with a validated Microlife BP A100 Plus model. Hypertension was defined as an average of
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44 185 two systolic blood pressure of ≥ 140 mmHg and diastolic of ≥ 90 mmHg in accordance with
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46 186 the Eighth Joint National Committee (JNC 8) criteria. Participants who reported being
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48 187 informed of their hypertensive status by health professional(s) were considered aware.
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50 188 Uncontrolled hypertension among those on treatment with at least one or more anti-
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52 189 hypertensive medications was defined as systolic blood pressure greater than or equal to
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54 190 140mmHg and diastolic blood pressure greater than or equal to 90mmHg, in accordance with
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56 191 JNC 8 criteria. The fasting blood glucose of each participant was measured with a validated
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58 192 ACCU-CHEK glucose monitoring apparatus in fasting state. Participants were diagnosed
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60 193 with diabetes if their fasting blood glucose level was equal or greater than 7.0 mmol/L or if
194 they were on current medications for diabetes. They were defined as pre-diabetic if the
195 fasting blood glucose fell between 6.1-6.9 mmol/L.³⁷

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3 196 Body weight was measured in light clothes to the nearest 0.01kg in the standing position
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5 197 using a Soehnle Scale (Soenle-Waagen Gmbh Co., Muurhardt, Germany) and height was
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7 198 measured to the nearest 0.1m by a stadiometer in standing position with closed feet (without
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9 199 shoes), holding their breath in full inspiration and Frankfurt line of vision.³⁸ Body mass index
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11 200 (BMI) was calculated as weight in kg divided by height in square metres (kg/m²). BMI was
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13 201 categorized in accordance with WHO³⁹ as <18.5kg/m², 18.5-24.9kg/m², 25.5-29.9kg/m² and
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15 202 >30.0kg/m² as underweight, normal, overweight and obese, respectively.

16 203 **Statistical analysis**

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18 204 Data were expressed as mean values ± standard deviations (SD) for continuous variables.
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20 205 Counts (frequencies=n) and proportions (%) were reported for categorical variables. A
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22 206 bivariate analysis was used to examine variables that have a significant association with
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24 207 hypertension and a p-value < 0.05 was considered statistically significant. The significant
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26 208 variables were included in the binary logistic regression and were adjusted for confounding
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28 209 factors. Analysis was carried out at a 95% confidence level. Statistical analysis was
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30 210 performed with the Statistical Package for Social Science (SPSS) version 21 for windows
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32 211 (SPSS Inc., Chicago, IL, USA).

33 212 **Results**

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35 213 Our analysis was based on 988 participants with complete data responses; 321 were males
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37 214 and 677 were females (response rate, 92%). Eight percent of the participants were excluded
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39 215 from the study because of incomplete documentation of blood pressure, blood glucose,
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41 216 weight or height. More than half of the respondents – 56.5% of males and 60.2% of females
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43 217 – were between the ages of 18 and 45 years. With respect to income level, 69.4% of men and
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45 218 80.9% of women, either had no source of income or earned less than R2000 per month. Table
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47 219 1 provides the descriptive characteristics of the participants.

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227 **Table 1 Demographic characteristics of the participants by sex**

Variables	Male (n=321) n(%)	Female (n=677) n(%)	Total (n=998) n(%)	p-value
Age group (years)				
18-25	40(12.5)	143(21.1)	183(18.3)	0.009
26-35	74(23.1)	149(22.0)	223(22.3)	
36-45	67(20.9)	116(17.1)	183(18.3)	
46-55	57(17.8)	110(16.2)	167(16.7)	
56-65	41(12.8)	99(14.6)	140(14.0)	
≥66	42(14.1)	60(8.9)	102(10.2)	
Level of education				
No formal schooling	62(19.3)	84(12.4)	146(14.6)	0.008
Grade 1-7	57(17.8)	99(14.6)	156(15.6)	
Grade 8-12	171(53.3)	409(60.4)	580(58.1)	
Tertiary	31(9.7)	85(12.6)	116(11.6)	
Monthly income (Rands)				
No income	134(41.7)	300(44.3)	445(44.6)	0.000
R150-2000	89(27.7)	248(36.6)	326(32.7)	
R2001-5000	74(23.1)	100(14.8)	174(17.4)	
R5001 and above	24(7.5)	29(4.3)	53(5.3)	
Marital status				
Single	193(60.3)	444(65.6)	637(63.9)	0.002
Married	115(35.9)	185(27.3)	300(30.1)	
Separated	1(0.3)	5(0.7)	6(0.6)	
Divorced	9(2.8)	13(1.9)	22(2.2)	
Widowed	2(0.6)	30(4.4)	32(3.2)	
Racial group				
Black	313(97.5)	666(98.4)	979(98.1)	0.026
Coloured	8(2.8)	9(1.3)	17(1.7)	
White	0(0.0)	2(0.3)	2(0.2)	
Type of employment				
Government employee	30(9.3)	33(4.9)	63(6.3)	0.000
Non-government employment	98(30.5)	133(19.7)	231(23.2)	
Self-employment	30(9.3)	32(4.7)	62(6.2)	
Students	19(5.9)	80(11.8)	99(9.9)	
Unemployed	115(35.8)	361(53.4)	476(47.7)	
Retired	29(9.0)	37(5.5)	66(6.6)	

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Prevalence, awareness and treatment of hypertension

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Of the 998 participants, 49.2% (n=491) were diagnosed with hypertension (Figure 1).

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Awareness of prior diagnosis of hypertension was reported by 339 participants (69.1% of

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total hypertensive individuals). Among those aware of having hypertension, nearly all

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(91.7%, n=311) were on anti-hypertensive medication. Treatment to target blood pressure

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occurred in 38.9% (n=121) of treated individuals.

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Factors associated with hypertension

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In bivariate analysis (Table 2), the following risk factors; ageing, male sex, lower level of

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education (below grade 8), being married, unemployed, lower income level, never drank

240 alcohol, sedentary lifestyle and both central and overall obesity were significantly associated
 241 with hypertension. Body mass index and age demonstrated positive linear associations with
 242 prevalent hypertension.

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244 **Table 2 Bivariate analysis showing the associated risk factors for hypertension**

Variables	Hypertensive	Normal BP	RR	95% CI	p-value
Sex					
Male	175(54.5)	146(45.5)	1.4	1.0-1.8	0.012
Female	316(46.7)	361(53.3)			
Age (years)					
≤25	35(19.1)	148(80.9)	-	-	0.000
26-35	66(29.6)	157(70.4)			
36-45	72(39.3)	111(60.7)			
46-55	133(67.7)	54(32.3)			
56-65	117(83.6)	23(16.4)			
≥66	88(86.3)	14(13.7)			
Level of education					
No formal schooling	77(52.7)	69(47.3)			0.000
Grade 1 to 7	118(75.6)	38(24.4)			
Grade 8 to 12	250(43.1)	330(56.9)			
Tertiary	46(39.7)	70(60.3)			
Marital status					
Never married	251(39.4)	386(60.6)	0.4	0.3-0.5	0.000
Married	211(64.3)	117(35.7)			
Employment					
Government employee	33(52.4)	30(47.6)	-	-	0.000
Non-government employee	104(45.0)	127(55.0)			
Self-employed	29(46.8)	33(53.2)			
Student	18(18.2)	81(81.8)			
Unemployed	252(52.9)	224(47.1)			
Retired	54(81.8)	12(18.2)			
Monthly income					
R2000	222(62.2)	135(37.8)	1.9	1.4-2.7	0.000
≥R2001	105(46.3)	122(53.7)			
Ever drink alcohol					
Yes	131(41.1)	188(58.9)	0.6	0.5-0.8	0.000
No	359(53.7)	310(46.3)			
Moderate intensity physical activity					
Yes	256(45.6)	305(54.4)	0.7	0.6-0.9	0.006
No	234(53.8)	201(46.2)			
Vigorous intensity physical activity					
Yes	58(37.9)	95(62.1)	0.6	0.4-0.8	0.002
No	433(51.5)	412(48.8)			
Body mass index (kg/m ²)					
Underweight	12(37.5)	20(62.5)	-	-	0.000
Normal	89(33.0)	181(67.0)			
Overweight	106(45.3)	128(54.7)			
Stage 1 obesity	114(55.6)	91(44.4)			
Stage 2 obesity	84(60.9)	54(39.1)			
Stage 3 obesity	76(72.4)	29(27.6)			
Central obesity derived from waist-to-hip ratio					
Yes	268(56.8)	204(43.2)	0.6	0.4-0.7	0.000
No	221(42.3)	301(57.7)			
WC derived central obesity					
Obese	355(54.7)	294(45.3)	0.5	0.4-0.7	0.000
Not obese	135(38.9)	212(61.1)			

245 RR= Relative risk; CI= Confidence interval

246 In the multivariate logistic regression model analysis (Table 3), ageing, being married, male
 247 sex, concomitant diabetes mellitus, lower income level, being unemployed and central
 248 obesity were the significant and independent determinants of prevalent hypertension.

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Table 3 Multivariate logistic regression analysis showing the predictors of hypertension

Variables	Beta	Wald	AOR (95% CI)	p-value
Age				
≤26 (Reference)				
Above 26	1.06	23.78	2.9(1.9-4.4)	0.005
Marital status				
Never married (Reference)				
Ever married	0.39	5.89	1.5(1.0-2.0)	0.015
Sex				
Female (Reference)				
Male	0.51	9.83	1.7(1.2-2.3)	0.000
Diabetes mellitus				
No (Reference)				
Yes	1.01	31.6	2.7(1.9-3.9)	0.000
Monthly income				
Middle-income >2000 (Reference)				
Low income ≤ 2000	0.49	9.48	1.6(1.2-2.2)	0.002
Employment				
Employed (Reference)				
Unemployed	0.33	4.01	1.4(1.0-1.9)	0.045
Central obesity derived from waist circumference				
No (Reference)				
Yes	0.63	10.0	2.1(1.5-2.8)	0.000

251 AOR=Adjusted odd ratios; CI= Confidence interval

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253 **Factors associated with hypertension awareness and control**

254 Hypertension unawareness occurred in 152 participants with significant difference by sex
 255 (p=0.005). The following factors; male sex, lower age, higher level of education, single
 256 status, current employment status, higher income earners, current smokers, alcohol users,
 257 non-diabetic and non-obese individuals were associated with hypertension unawareness in the
 258 study (Table 4).

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266 **Table 4 Bivariate analysis showing the associated factors of hypertension awareness**

Variables	Aware	Unaware	RR	95% CI	p-value
Sex					
Male	108(61.7)	67(38.3)	0.6	0.4-0.9	0.005
Female	232(73.4)	84(26.6)			
Age (years)					
<45	79(23.2)	95(54.6)	0.5	0.1-0.3	0.000
>45	261(82.3)	56(17.7)			
Level of education					
No formal schooling	57(73.1)	21(26.9)	-	-	0.002
Grade 1-7	93(78.8)	25(21.1)			
Grade 8-12	168(67.2)	82(32.8)			
Tertiary	22(48.9)	23(51.1)			
Marital status					
Never married	152(60.6)	99(39.4)	0.5	0.3-0.7	0.000
Married	161(76.3)	50(23.7)			
Employment status					
Employed	99(59.3)	68(40.7)	0.5	0.3-0.7	0.000
Unemployed	241(74.4)	83(25.6)			
Monthly income (Rands)					
<R2000	276(71.7)	109(28.3)	1.7	1.1-2.6	0.018
>R2000	64(60.4)	42(39.6)			
Current smokers					
Yes	33(50.0)	33(50.0)	0.4	0.2-0.7	0.000
No	307(72.2)	118(27.8)			
Ever drink alcohol					
Yes	67(50.8)	65(49.2)	0.3	0.2-0.5	0.000
No	272(76.2)	85(23.8)			
Diabetes mellitus					
Yes	114(85.1)	20(14.9)			
No	226(63.3)	131(36.7)	0.3	0.2-0.5	0.000
Obesity					
Yes	260(73.4)	94(26.6)	2.5	1.5-3.2	0.001
No	79(58.1)	57(41.9)			

267 RR= Relative risk; CI= Confidence interval

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270 Among the participants on treatment for hypertension (n=311), only level of education (no
 271 formal schooling) was associated with uncontrolled hypertension. Concomitant diabetes
 272 mellitus was not significantly associated with uncontrolled hypertension (Table 5).

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279 **Table 5 Bivariate analysis showing the factors associated with hypertension control**

Variables	Controlled HTN	Uncontrolled HTN	RR	95% CI	p-value
Sex					
Male	34(35.4)	62(64.4)	0.8	0.5-1.3	0.262
Female	86(40.0)	129(60.0)			
Age (years)					
<45	31(47.7)	34(52.3)	1.6	0.9-2.8	0.061
>45	89(36.2)	157(63.8)			
Level of education					
No formal schooling	11(23.9)	35(76.1)	-	-	0.048
Grade 1-7	32(36.0)	57(64.0)			
Grade 8-12	68(43.0)	90(57.0)			
Tertiary	10(55.6)	8(44.4)			
Marital status					
Never married	56(42.4)	76(57.6)	0.8	0.5-1.2	0.165
Married	65(36.3)	114(63.7)			
Employment status					
Employed	36(41.4)	51(58.6)	0.9	0.5-1.4	0.344
Unemployed	85(38.1)	138(61.9)			
Monthly income (Rands)					
<R2000	98(38.9)	154(61.1)	1.0	0.6-1.8	0.551
>R2000	23(39.0)	36(61.0)			
Current smokers					
Yes	11(39.3)	17(60.7)	1.0	0.5-2.3	0.544
No	109(38.5)	174(61.5)			
Ever drink alcohol					
Yes	18(32.7)	37(67.3)	0.7	0.4-1.3	0.204
No	102(39.8)	154(60.2)			
Diabetes mellitus					
Yes	87(56.9)	66(43.1)	0.7	0.4-1.1	0.052
No	105(66.5)	53(33.5)			
Obesity					
Yes	76(36.8)	125(62.2)	0.9	0.6-1.5	0.398
No	44(40.0)	66(60.0)			

280 RR= Relative risk; CI= Confidence interval; HTN= Hypertension

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282 **Discussion**

283 To the best knowledge of the authors, this is the first paper addressing epidemiological gaps
284 regarding the prevalence, awareness, treatment and control of hypertension in the Buffalo
285 City Metropolitan Municipality (BCMM). We found a high prevalence of hypertension
286 (49.2%) in our study population. There seems to be an upward trend in the prevalence of
287 hypertension in the country which is rather unsurprising, given rapid urbanization and its
288 consequent effects on population health. Our result is higher than that in Day et al.'s²³ study,
289 which reported a 40% prevalence of hypertension among South African adults in 2010. A
290 lower prevalence of hypertension (38.9%) was reported by Peer et al.²⁵ among black urban
291 South African adults between the ages of 24 and 65 years in Cape Town. A nationally
292 representative house-hold survey in South Africa which included individuals aged 15 years
293 and above reported a prevalence range of 9% in Limpopo Province to 22.3% in Northern

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3 294 Cape Province.³⁴ The highest prevalence of hypertension (12.4%) was found among the black
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5 295 South African population. Weimann et al.⁴⁰ estimated a higher prevalence, at 37% and 52%,
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7 296 in the Eastern Cape and Northwest Provinces. The higher prevalence of 49.2% found among
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9 297 our sample is comparable to Northwest Province's 52%, but higher than the percentage
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11 298 reported for the Eastern Cape Province by Weimann et al.⁴⁰ with an almost similar age
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13 299 distribution. Our result was obtained from the primary health care setting and thus, **may not**
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15 300 **be representative of the overall population.** However, considering the age distribution of the
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17 301 study participants, with more than half below the of age 45, such a high prevalence of
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19 302 hypertension further signifies the need for urgent interventions as population ageing is often
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21 303 associated with a higher prevalence of hypertension.

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23 304 There is a wide variation in the prevalence of hypertension across sub-Saharan Africa; from
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25 305 23% among Zambian and Angolan adults to 26% in adults in four selected sub-Saharan
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27 306 African countries.^{10-12,41} Akpan et al.⁹ reported a prevalence of 48.3% among rural adults in
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29 307 the eastern part of Nigeria, while a 44.7% prevalence was documented among rural Ghanaian
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31 308 adults. Similar trends of increasing hypertension prevalence have been reported worldwide;
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33 309 Chow et al.³⁰ found a prevalence of 40.8% among rural and urban dwellers in selected high-
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35 310 income countries (Canada, Sweden, United Arab Emirates), middle-income countries
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37 311 (Argentina, Brazil, Chile, Poland, Turkey, Malaysia, South Africa, China, Colombia and
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39 312 Iran) and low-income countries (Bangladesh, India, Pakistan and Zimbabwe). A higher
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41 313 prevalence was reported in certain other developing countries, with prevalence ranging from
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43 314 50.7% to 79.8% among adults living in urban areas of India, Latin America and China.^{42,43}
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45 315 Our finding further supports the epidemiological shift of non-communicable diseases to
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47 316 developing nations.^{13,44}

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51 318 Although a thorough comparison of various studies cannot be done as a result of differences
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53 319 in the definitions, methodology and populations used, the findings from this study indicate
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55 320 that South Africa is already at the forefront of the epidemiologic transition. The shift is being
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57 321 exacerbated by advancements in technology attributed to urbanization and westernization.
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59 322 These are both the driving forces of the increasing burden of non-communicable disease risk
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323 factors of which hypertension is predominant. It is linked to the adoption of unhealthy
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325 lifestyle behaviours, poor dietary practices and poor engagement in physical activity, leading
to obesity, and ultimately, cardiovascular risk factors like hypertension. Our findings signal a

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3 326 looming burden of non-communicable disease among the study participants if urgent actions
4 are not taken.
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8 329 We found ageing, male sex, being married, unemployment status, poverty, sedentary
9 lifestyles, obesity and diabetes mellitus as the important determinants of prevalent
10 330 hypertension in the study population. Several other studies have also established a link
11 331 between these risk factors. Pires et al.¹² affirmed that increasing age, lower level of education
12 332 and increasing weight were associated with hypertension. Additionally, Guwatudde et al.¹¹
13 333 found diabetes to be significantly associated with hypertension. Increasing age is often
14 334 associated with changes in the body systems, including the cardiovascular system such as the
15 335 heart and arteries. Old people suffer a great deal of cardiovascular risk factors, especially
16 336 hypertension.⁴⁵
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25 339 We found a higher prevalence of hypertension in individuals with a lower level of education
26 340 (below grade 8). These individuals are most likely to be unemployed and to earn less than
27 341 R2000 per month. The association between level of education and health is rather complex; it
28 342 can be assumed that the more educated an individual is, the more knowledgeable he will be
29 343 on matters of health. Whether this assumption is true in our study population is rather
30 344 speculative. Cutler and Lleras-Muney⁴⁶ reported that education increases knowledge.
31 345 Educated individuals are more likely to be receptive to new developments, including newly
32 346 approved drugs, and are often compliant with drug use.^{47,48} Our study participants with
33 347 hypertension were poor and unemployed. Their socio-economic status limited their access to
34 348 healthy foods and increased their consumption of readily available, cheap foods which
35 349 contribute to risk factors such as obesity and hypertension. This should, however, be
36 350 interpreted with caution, as being unemployed does not necessarily denote a low income.
37 351 Underlying factors associated with unemployment, such as psychological stress, could
38 352 contribute to the high prevalence of hypertension among this cohort. We found a higher
39 353 prevalence of hypertension among men. Female hormonal effect is believed to be protective⁴⁹
40 354 and since the majority of the women in this study were below the age of 50, this could be a
41 355 plausible reason for our findings. Also, obesity, work stress, physical inactivity, alcohol
42 356 intake and salt intake have been reported to be high in men, resulting in higher odds of men
43 357 developing hypertension.⁵⁰
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3 359 There is a substantial intersection between hypertension and diabetes because of the shared
4 360 metabolic pathway and risk factors.⁵¹⁻⁵³ Hypertension is always found in more than half of
5 361 individuals with type-2 diabetes and the chances of developing hypertension among persons
6 362 with type-2 diabetes is more than double than that amongst non-diabetic persons.⁵⁴ Also, as
7 363 shown by Murphy et al. and Bromfield & Munter,^{55,56} there is a recognized link between
8 364 hypertension, obesity, smoking, harmful use of alcohol and physical inactivity and a large
9 365 percentage of the hypertension burden is attributed to these factors. The relationship between
10 366 hypertension and obesity has long been established. Obesity increases the chance of
11 367 developing hypertension and increases the risk of developing cardiovascular
12 368 complications.^{57,58} As reported by Pandey et al,⁵⁹ smoking increases the prevalence of
13 369 hypertension.⁵³ Physical inactivity is a precursor to obesity and hypertension. Physical
14 370 inactivity is responsible for 20% of hypertension cases.⁶⁰
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25 372 The present study further illustrates that the majority (69.1%) of the hypertensive patients
26 373 were aware of their status, and of these, almost all (91.7%) were already on treatment with
27 374 only 38.9% achieving control. This awareness rate is higher than the 24% awareness rate
28 375 reported among South Asian adults.⁶¹ There is a wide variation of hypertension awareness
29 376 across African countries with rates ranging from 8% in Nigeria to 81% among elderly
30 377 individuals in Tunisia.⁶² Also, the study settings being health facilities might have contributed
31 378 to the high awareness prevalence recorded in this study.
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38 380 Despite scientific successes in anti-hypertensive drug discoveries, achieving treatment targets
39 381 remains a serious challenge. Although nearly all of the participants with prior diagnosis were
40 382 already receiving treatment for hypertension, a commendable effort, only 38.9% achieved
41 383 treatment targets. This is somewhat better than previous studies conducted in Mthatha, South
42 384 Africa (25.5%) and Zimbabwe, (32.8%).^{22,31} It is also comparable to the rate of control of
43 385 hypertension (36.4%) reported by Day et al.²³ in a household survey conducted among South
44 386 African adults in 2010. Generally, hypertension control has been reported to be sub-optimal
45 387 in Africa, ranging from 2.6% in Kenya to 42.2% in Ethiopia.⁶²⁻⁶⁴
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52 388 We observed that men, those earning more than R2000 per month, those aged under 45 years,
53 389 employed, cigarette smokers and alcohol users had higher rates of hypertension unawareness.
54 390 Men have been reported to have higher odds of developing hypertension and the high rate of
55 391 unawareness among them is not surprising. Females have been recognized as more likely to
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3 392 seek healthcare than men.⁶⁵ Traditional gender roles in Africa account for the under-
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5 393 utilization of health facilities among men; men are the breadwinners and are perceived as
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7 394 healthy.^{66,67} Hence, they rarely seek health facilities for screening purposes unless they are
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9 395 sick. Hypertension is largely asymptomatic and this being the case, an affected individual
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11 396 will rarely seek healthcare. Our findings have serious public health consequences, due to the
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13 397 clustering of cardiovascular diseases among the individuals with hypertension unawareness.
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15 398 Younger individuals are unlikely to visit health facilities without any major sickness. Hence
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17 399 the high rate of unawareness in those younger than 45 years. Besides, this cohort of
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19 400 individuals are pre-occupied by their jobs. Older individuals tend to have multi-morbidity and
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21 401 as such, would have had several opportunities to be screened for non-communicable diseases.
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23 402 Alcohol-and nicotine-dependence may explain our findings of high unawareness among
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25 403 alcohol users and current cigarette smokers, respectively.

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27 404 We found a high rate of uncontrolled hypertension (62.4%) in our study participants. Several
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29 405 factors have been implicated for the poor control of hypertension in Africa, which are
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31 406 generally related to deficiencies in the healthcare system, non-adherence to medication
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33 407 regimens by patients and physicians' inertia to optimize treatment of hypertension.^{22,62}
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35 408 Several studies have documented the unavailability of anti-hypertensive drugs as well as non-
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37 409 adherence to clinic visits by patients as a result of lack of transportation and time.^{12,68,69} Poor
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39 410 treatment outcomes in Africa has been documented extensively.^{13,31,62,70,71} In comparison,
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41 411 higher levels of control (64.8% and 66%) of hypertension were reported in the USA and
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43 412 Canada, respectively.^{72,73} This is not a surprise as the management of hypertension is costly
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45 413 due to its chronic nature. Developed countries have been recording successes in the reduction
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47 414 of the burden related to hypertension and other non-communicable diseases.⁷⁴

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49 415 Also, participants who had diabetes mellitus were found to have a lower rate of controlled
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51 416 hypertension. Multi-morbidity with significant risks of poly-pharmacy are some of the
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53 417 reasons for the poor control of blood pressure in those with concomitant diabetes. A study in
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55 418 a similar setting by Adeniyi et al.²² found poor control of blood pressure among individuals
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57 419 with concomitant diabetes. Illiteracy was associated with poor blood pressure control among
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59 420 our study participants already on treatment for hypertension. Poor treatment outcomes among
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61 421 individuals with no formal education is not surprising. Despite the availability of medications
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63 422 at the health facility, some of our patients regularly miss appointments and fail to collect
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65 423 medications. Education is said to be "power" and Cutler and Lleras-Muney⁴⁶ assert that
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67 424 education increases knowledge. There is a possibility of a lack of adequate knowledge on the

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3 425 importance of medication use in the control of hypertension among illiterate persons. In
4 426 addition, the benefits of positive lifestyle behaviours for the control of hypertension might not
5 427 be fully appreciated by such individuals. Likewise, lack of education generally leads to
6 428 poverty; thus poorly educated patients are less likely to be able to purchase essential drugs for
7 429 hypertension or to eat as healthily, as healthy foods tend to cost far more low-cost,
8 430 carbohydrate-rich foods.⁷⁵
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14 432 **Strengths and limitations**

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16 433 The limitations of the study cannot be ignored. Firstly, this was a cross-sectional study, hence
17 434 causality cannot be ascribed to the determinants. Our findings should be interpreted with
18 435 caution in view of the convenience sampling of the participants at the primary health care
19 436 facilities. We also did not obtain information on the hypertensive medications being used and
20 437 therefore, could not gain a full understanding of the uncontrolled hypertension in our study
21 438 participants. Notwithstanding these limitations, the findings of the study provide useful
22 439 epidemiological data in view of the large sample size, the large out-patient clinics selected
23 440 and the previously understudied setting.
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32 441 **CONCLUSION**

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34 442 The findings of a high prevalence of hypertension and sub-optimal blood pressure control of
35 443 hypertension requires the urgent attention of health authorities in Buffalo City Metropolitan
36 444 Municipality. Also, the clustering of cardiovascular risk factors in individuals with
37 445 hypertension suggests that an integrated strategy addressing all the non-communicable
38 446 diseases will be needed to mitigate the looming epidemic. Strategies aimed at the prevention
39 447 of hypertension, its early diagnosis and treatment to target blood pressure levels are needed in
40 448 BCMM. Also, the re-engineering of the primary health care system will be crucial towards
41 449 dealing with the burden of non-communicable diseases in the region.
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49 450 ***Consent for publication***

50 451 All authors approved the submission of this final draft towards publication in a peer reviewed
51 452 journal.
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55 454 ***Availability of data and materials***

56 455 Data from this study will be made available on request.
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3 4564 457 **Competing interests**

5 458 The authors declare no conflict of interest.

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16 46417 465 **Authors' contributions**18 466 EOO, DTG and OVA conceptualised, designed and drafted the paper. ES participated in data
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21 467
22 468
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Figure 1: Prevalence of Hypertension

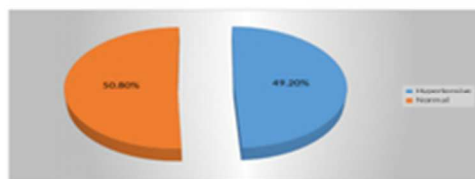


Figure 1: Prevalence of Hypertension

Figure 1. Prevalence of Hypertension

30x30mm (300 x 300 DPI)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract. – Page 1 (b) Provide in the abstract an informative and balanced summary of what was done and what was found – Page 2
Introduction		
Background/rationale- pg	2	Explain the scientific background and rationale for the investigation being reported – page 3 to 4
Objectives	3	State specific objectives, including any pre-specified hypotheses – Page 4
Methods		
Study design	4	Present key elements of study design early in the paper – Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection – Page 4 to 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants – Page 4 to 5 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – Page 6 to 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group – Page 6 to 7
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at – Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why – Page 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding – Page 7 (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy – Page 7 (e) Describe any sensitivity analyses

Continued on next page

Results – Pg 7

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders – Page 7 to 8 (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included – Page 8 to 12. (b) Report category boundaries when continuous variables were categorized. Page 8 to 12 (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives – Page 12 to 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias – Page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence – Page 17
Generalisability	21	Discuss the generalisability (external validity) of the study results – Page 17

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based – Page 18
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.